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INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭ'lo
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

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RADIATION DATA AND REPORTS

Volume 13, Number 10, October 1972

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

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U.S. ENVIRONMENTAL PROTECTION AGENCY

William D. Ruckelshaus, Administrator

Reports

A Comparison of Film Badges and Thermoluminescent Dosimeters Used for Environmental Monitoring[1]

Charles K. Fitzsimmons, William Horn, and William L. Klein [2]

Data obtained from two concurrent dosimetry networks operated by the National Environmental Research Center, Las Vegas, Nev., are compared. One network utilizes film badges and the other, thermoluminescent dosimeters. Gamma exposures from a few mR to approximately 1 R due to both natural background and fission products in the environment are more easily and accurately measured by the TLD system. Where the minimum detectable exposure for film is about 45 mR, the TLD sensitivity is on the order of 1 mR (which allows measurement of monthly background exposures). The insensitivity of TLD's to environmental heating, humidity, light damage, and pressure makes them ideal for use in the extreme conditions encountered in the desert. Heat damage to the film was seasonal with the greatest losses occurring in the summer. During July 1967, 71 percent of the film badges issued were heat or light damaged, while no loss of TLD data occurred. No background information was obtained from film data during 1967, but the geographical variations in background exposure rates were clearly disclosed by the TLD's.

In accordance with a Memorandum of Understanding, the National Environmental Research Center—Las Vegas (NERC–LV) provides an offsite radiological safety program for the Atomic Energy Commission in support of nuclear tests conducted on the Nevada Test Site (NTS) complex.

As one portion of the offsite radiological safety program, the Dosimetry Unit of the NERC–LV has a primary mission to document offsite gamma radiation exposures above environmental background resulting from specific nuclear tests.

Since inception of the program in 1954, integrating dosimeter readings have been used to supplement offsite exposure data. Film badges were the dosimeters of choice at that time. However, because interest in the field of radiological health has shifted during recent years to the measurement of smaller exposures, the inherent properties of the film badge dosimeter severely limited expansion of the program into this area. The sensitivity, accuracy, and reliability of the film badge were found to be inadequate for the gamma radiation levels of interest.

During this same period, considerable research on thermoluminescent dosimeters (TLD's) was being performed by a number of investigators. The properties of the TLD as described in the literature seemed more suitable for the needs of the NERC–LV. In 1965, after considerable field testing, a TLD system was incorporated into the film badge dosimetry network. As a result, over 2 years of side-by-side data have been accumulated from approximately 80 field locations.

This report presents a comparison and discussion of the film badge and TLD data.

Film badge network

Before 1961, film badges were issued to off-

[1] This study performed under a Memorandum of Understanding for the Nevada Operations Office, U.S. Atomic Energy Commission.

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site residents and placed at strategic locations for specific nuclear tests. The film packet used was DuPont type 556, containing a two-component packet in a paper wrapper, emulsion No. 508, with a claimed detection range from 30 mR to 5 R, and emulsion No. 834, with a detection range from 3 R to 10 R. In 1963, the number of permanent stations in the film badge network was 66, in addition to a monthly dosimeter exchange with 130 offsite residents. The present program consists of 100 permanent offsite stations and 119 offsite residents.

Although the DuPont 556 film packet was the most suitable field dosimeter available at the time, serious problems were encountered. A high percentage of the film badges was damaged by heat, light, and moisture. In 1963, an alternative to the DuPont 556 film packet was investigated. Since offsite radiation monitoring involved exposures less than 5 R, it was felt that a single component low-range film packet would be adequate. As a result, a new film badge holder was designed incorporating DuPont type 545 film with a detection range from 30 mR to approximately 4 R. Although this reduced the initial film badge cost by 50 percent and increased the sensitivity of the dosimeter somewhat, the new film packet was as susceptible to heat, light, and moisture damage as its predecessor.

During this same period, interest in the field of radiological health had shifted to the measurement of smaller exposures. At this point, the inherent limitations of the film badge became a major obstacle to the growing needs and obligations of the Dosimetry Unit. In 1965, several nonfilm dosimeters were investigated and evaluated.

TLD network

After investigating various thermoluminescent and glass dosimeters, the Edgerton, Germeshausen, and Grier, Inc., (EG&G) Thermoluminescent Dosimetry System was field tested. The EG&G system utilized the TL–12 thermoluminescent dosimeter and the TL–2B dosimeter reader. The detection medium of the dosimeter consists of a layer of CaF_2:Mn bonded to a helical heater element that is encapsulated in a gas-filled glass envelope. The detector is housed in an aluminum-tin-lead shield designed to compensate for the detector over-response in the low energy region of the gamma ray spectrum and to protect the detector from light exposure. The dosimeter reader accepts the TLD in a light tight chamber, heats it with a regulated current and converts the emitted light energy into an electrical signal for display on the built-in strip chart recorder.

Preliminary field investigation involved the use of 10 TLD's for each of two NTS events: Sulky, a Plowshare experiment, and the Transient Nuclear Test (TNT) of a Kiwi Reactor. During each event, two TLD's were retained in Las Vegas as controls and eight were placed in strategic locations or carried by EPA monitoring personnel. Although the field dosimeters yielded slightly higher readings than the controls, evaluation on a larger scale was advisable. Consequently, EG&G furnished 55 dosimeters for monitoring of Project Palanquin in April 1965. During each evaluation, 10 dosimeters were retained as controls. Each of the remaining 45 dosimeters was packaged in a polyethylene envelope with one DuPont type 555 film packet and one DuPont type 556 film packet. The type 556 film had been preexposed to 100 mR of cobalt-60 radiation in an attempt to gain greater sensitivity to low exposures. The dosimetry packages were placed on stakes within the expected trajectory and carried in monitoring aircraft and by field personnel.

After a 10 day exposure in the field, the TLD's were taken to EG&G in Santa Barbara, Calif. for reading. The film badges were sent to Mercury, Nev., for processing. The results obtained from Santa Barbara indicated that the manufacturer's claims concerning the minimum dose resolution of 5 mR and a coefficient of variation of 10 percent were, in fact, conservative. In addition, it was found that the preexposed film performed very poorly and this technique was abandoned. The TLD system held promise to fulfill the growing need for greater sensitivity and accuracy in measuring environmental gamma exposure.

An EG&G TLD system was obtained and put into operation during August 1965. The results of the first 4 months of operation indicated that

before the full potential of the system would be realized, a number of objectives had to be met. These objectives were to (1) perfect a system of reader calibration, (2) establish a correction factor for each dosimeter, (3) determine the internal background due to potassium-40 activity within the dosimeter, (4) ascertain the significance of fading over extended periods of time, and (5) determine the precision of the system. The results of studies and solutions to problems in these areas, as well as the development and growth of the TLD network, are discussed in another report (*1*).

The bulk of the data used for comparison in this report was collected during 1966 and 1967 when 80 TLD stations were in operation. The data represent exposures from fission product gamma radiation in the range from 5 mR to approximately 1 R. The energy response of any dosimeter is a function of the shielding employed as well as the detection medium. The energy response of the TL–12 is shown in figure 1.

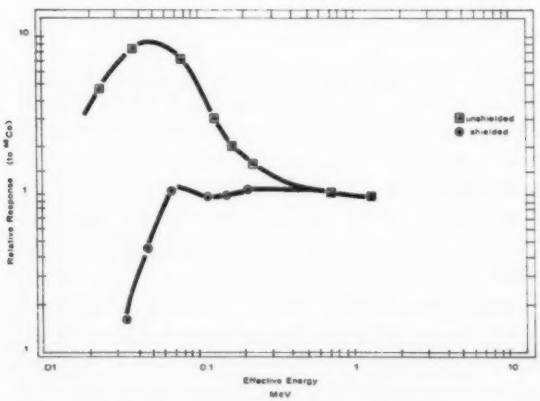

Figure 1. Gamma energy response of thermoluminescent CaF_2:Mn

Comparison of field data

Data from the routine monitoring network

Data from the routine stations are used primarily to establish background exposure rates, even though the network owes its existence to the need for measurement of possible biologically significant exposures due to specific nuclear tests. Background, in this sense, refers to the exposure from all ionizing radiation in the environment which cannot be attributed to any specific manmade source. Thus, it is possible in some cases that *background* includes the exposure from a residual trace of long-lived fission products as well as from the naturally-occurring radionuclides and cosmic radiation. The observed variation in background levels from place to place is a function of the intensity of all three contributors, manmade, terrestrial, and cosmic.

The film badge has proven incapable of providing this background information. Out of 6,454 film badges placed at the offsite stations during 1967, only 257 or 4.0 percent had a reported value greater than the detection limit. Film badges that were damaged or read below the detection limit were reported as zero. Table 1 presents a summary of dosimeters issued, those damaged or lost, and those having a reading greater than zero. Of 2,461 TLD's issued in 1967, only 10 failed to produce usable data. If film badges are left in the field long enough to obtain a reading over the 30 to 50 mR threshold, the chance of heat or light damage becomes a near certainty. Film badges left in the field for 2 months which do not become unreadable because of severe heat damage often read 40 to 50 mR, about 100 percent greater than the expected exposure. Little use is made of the routine film badge data since the TLD's perform so well.

The basic purpose of any monitoring network is to detect exposures above natural background. However, small offsite exposures due to nuclear testing are seldom detected even by the TLD's at routine stations because the signal-to-noise ratio is unfavorable. Typical monthly backgrounds range from 10 to 20 mR. Variation in the monthly background exposure at a given location can be as great as ±50 percent. Thus, net exposures less than about 10 mR which are still of interest may be missed. Greater sensitivity is obtained by placing special dosimeters in the field for specific events and using the background values derived from the routine data to calculate net exposures. In order to

Table 1. Summary of dosimeters issued to routine stations in 1967

Month (1967)	Number of dosimeters used	Number lost or damaged	Percent lost or damaged	Number reporting values greater than zero[a]	Percent greater than zero
Thermoluminescent dosimeters:					
January	209	0	0	209	100
February	210	0	0	210	100
March	207	0	0	207	100
April	216	0	0	216	100
May	177	6	3.4	171	96.6
June	204	0	0	204	100
July	222	0	0	222	100
August	248	1	.4	247	99.6
September	246	3	1.2	243	98.8
November[b]	261	0	0	261	100
December	261	0	0	261	100
Totals	2,461	10	.4	2,451	99.6
Film badges:					
January	588	18	3.1	17	2.9
February	482	12	2.5	18	3.7
March	592	132	22.3	31	5.2
April	574	64	11.1	50	8.7
May	491	146	29.7	20	4.1
June	600	400	66.6	24	4.0
July	580	413	71.2	0	0
August	632	177	28.0	18	2.8
September	628	60	9.6	21	3.3
November[b]	630	15	2.4	31	4.9
December	657	12	1.8	27	4.1
Totals	6,454	1,449	22.5	257	4.0

[a] Film badges that were damaged or read less than the detectable level were reported as zero.
[b] Reporting periods were longer than 1 month on the average, and only 11 reports were made in 1967. The gap was made up by skipping the October report.

accumulate data, the dosimeters used must be sensitive to the low background exposure of one month's time.

Data from monitoring a nuclear waste disposal site

Four routine stations in the monitoring network are located on the fence surrounding the Nuclear Engineering Company's radioactive waste disposal site near Beatty, Nev. Each station has five film badges and three TLD's. The stations were established at the request of the Nevada State Health Department. Subsequently, the stations have provided side-by-side data which have been used to compare film badge and TLD performance. Exposures range from about 40 mR to nearly 700 mR.

Average values of three TLD and five film badge responses for 1 year at the disposal site are paired and ranked by TLD response in table 2. The data were collected from January 4, 1967, to January 11, 1968. Each value represents the exposure in mR for approximately 1 month. The great monthly variations are the result of burials and other movement of radioactivity within the fenced area. A linear regression was performed on the data and yielded $y = -1.01 + 1.03x$, which is an excellent agreement between the two dosimeters (figure 2). The slope of 1.03 has a coefficient of variation of only 3.22 percent and a correlation coefficient of 0.98.

Thirty-four film badge readings in this group were greater than 45 mR, while only six were less. The excellent correlation is attributable to the ideal exposure range, 40 to 700 mR, for the film. What is not shown by these figures is that all zero values or unreadable (damaged) film badges were deleted from table 2. Frequency of heat damage followed the same seasonal trend as it did for the other badges issued, 27 percent were heat damaged, and 1 percent indicated zero. No data were missing from the 132 TLD's issued during the same period.

Another statistical test was made on the Nuclear Engineering Company data. Individual readings rather than averages were used so that

Table 2. Paired average thermoluminescent dosimeters-film badge monthly exposures from Nuclear Engineering Company Site

Location	Thermoluminescent dosimeters (mR)	Film badge[a] (mR)
North fence	37	79
	38	44
	43	23
	50	34
	52	81
	60	49
	62	48
	62	55
	63	58
	93	98
South fence	46	39
	64	40
	64	96
	71	113
	72	65
	98	104
	187	183
	269	267
	364	367
	537	671
East fence:	61	70
	67	34
	75	96
	98	106
	101	90
	102	110
	126	95
	147	131
	150	182
West fence	48	48
	62	95
	63	47
	72	52
	79	110
	81	71
	121	123
	185	141
	297	321
	551	505
	679	663

[a] Minimum detectable level varied, but was generally about 30 mR.

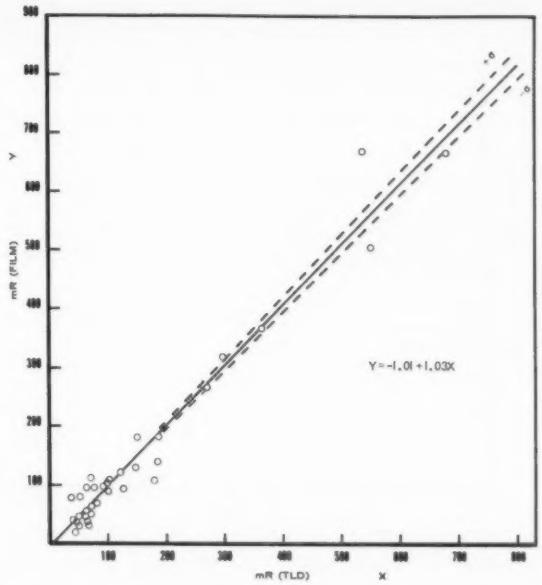

Figure 2. Correlation of film and TLD response from Nuclear Engineering Company data

a better estimate of the error term would be made. The hypothesis that the mean film badge response is equal to the mean TLD response for a given exposure was tested using a two factor design. Calculations were made using an IBM 1130 computer. The two factors were: (a) monthly effects, and (b) type of dosimeter (film badge or TLD). As expected, there was a very large monthly effect. There was also a significant difference at the 95-percent confidence level between film badge and TLD means; however, the regression analysis previously done suggests that the difference was probably small. The interaction term (A×B) was also significant, indicating a possible seasonal effect on the film response. The validity of this interpretation is supported by the fact that heat damage to the film is seasonal and, therefore, sensitivity might be assumed to be seasonal also. Furthermore, studies have shown (*1*) that environmental temperature, humidity, and pressure have no detectable effect on TLD response. It is likely then, that the interaction term reflects a greater degree of variation in film response than in TLD response.

Data from a Plowshare experiment

EPA monitoring activities for Project Buggy I, a Plowshare nuclear cratering experiment conducted on March 12, 1968, included six arcs of thermoluminescent dosimeters placed across the expected cloud trajectory. The dosimeters yielded a series of exposure profiles across the cloud path at 8 (Arc 1), 10, 35, 51 (Arc 4), 82, and 170 miles downwind from ground zero. The data also defined the line of maximum exposure, the approximate cloud width with distance, and the decrease of exposure as a function of distance. On two arcs, Arc 1 and Arc 4, film badges were placed alongside the TLD's.

Two TLD's and two film badges were placed on each stake of Arc 1. One of each was collected at H + 3 hours and the data plotted as "first

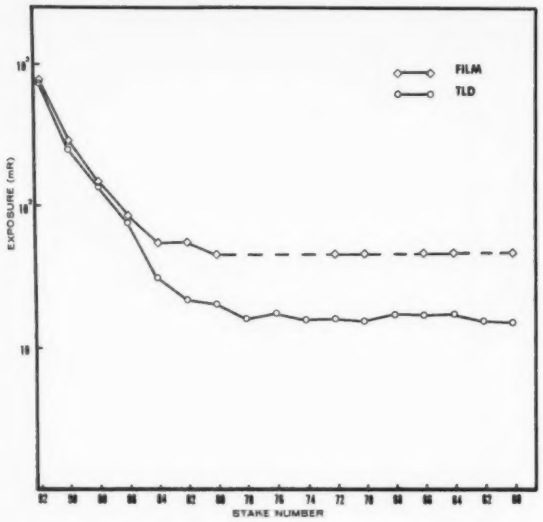

Figure 3. Cloud profile, Arc 1, Buggy 1, first pickup

pickup" in figure 3. The remaining TLD's and film badges were collected on D + 7 days. These data are plotted as "second pickup" in figure 4. The difference in low level sensitivity is shown plainly in these two plots. Above 80 mR, film and TLD responses are comparable, but there is increasing disagreement between the film badge and TLD data as the exposure level decreases. Below 45 mR there is no reported film response at all. Under these experimental conditions, 45 mR appears to be the minimum detectable exposure for the film (DuPont 556 packet, the same as that used at the Nevada Test Site for personnel monitoring).

The film and TLD data were paired for a statistical comparison of response to common exposures. Of the 34 film badges issued, only 19 provided positive data. Consequently, only the 19 film badge-TLD data pairs shown in table 3 were used in the analysis.

The first linear regression analysis, performed on all 19 data pairs, yielded the relationship, $y = 21.36 + 1.086x$, where y represents the film response and x the TLD response. The data are plotted in figure 5. The slope of the regression line was equal to 1.086 with a coefficient of variation of 1.64 percent and a correlation coefficient of 0.99.

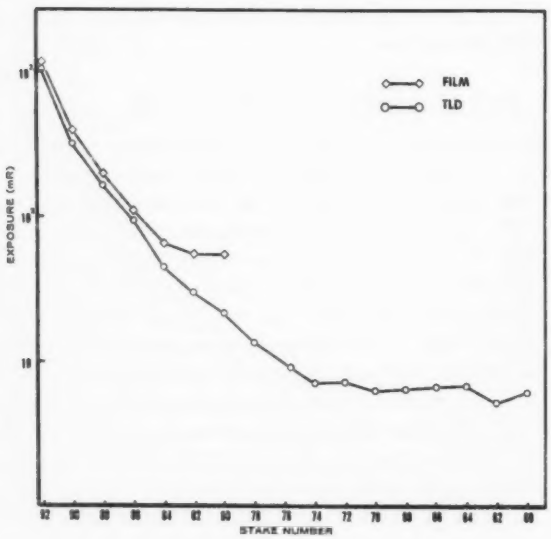

Figure 4. Cloud profile, Arc 1, Buggy 1, second pickup

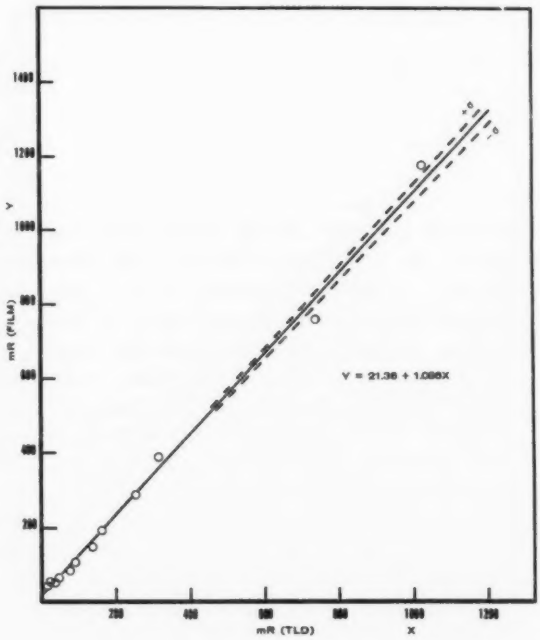

Figure 5. Correlation of film and TLD response from Arc 1, Buggy 1

Table 3. Paired thermoluminescent dosimeter-film badge data from Arc 1, Buggy 1.

Thermoluminescent dosimeters (mR)	Film badge (mR)
14.8	45
15.4	45
16.0	45
17.0	45
17.2	45
20.4	45
21.4	55
21.7	55
29.8	55
31.1	55
44.5	65
75.6	85
92.8	110
135.5	150
162.1	195
252.9	290
313.8	390
734.3	760
1,025.4	1,175

As can be seen from table 3, the film showed little sensitivity to small changes in exposures below 55 mR. A second linear regression analysis was performed on the lowest 13 data pairs. The result of the analysis (figure 6), yielded the relation, $y = 32.9 + 0.770x$. The slope of the regression line was equal to 0.770 with a coefficient of variation of 5.67 percent and a correlation coefficient of 0.98.

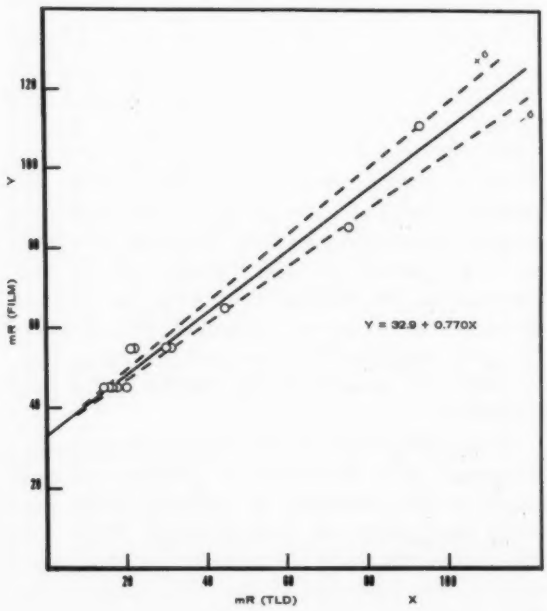

Figure 6. Correlation of film and TLD response from Arc 1, Buggy 1, lowest 13 data pairs

One DuPont type 545 film badge, the same type as is used in the dosimetry network, was placed on each stake along Arc 4, 51 miles from ground zero. Exposure profiles, as detected by both film badges and TLD's, are plotted in figure 7. The conspicuous lack of film badge data points results from the fact that exposure levels were near or below the minimum detectable limit of the film. Table 4 lists the paired values for which positive film data were available.

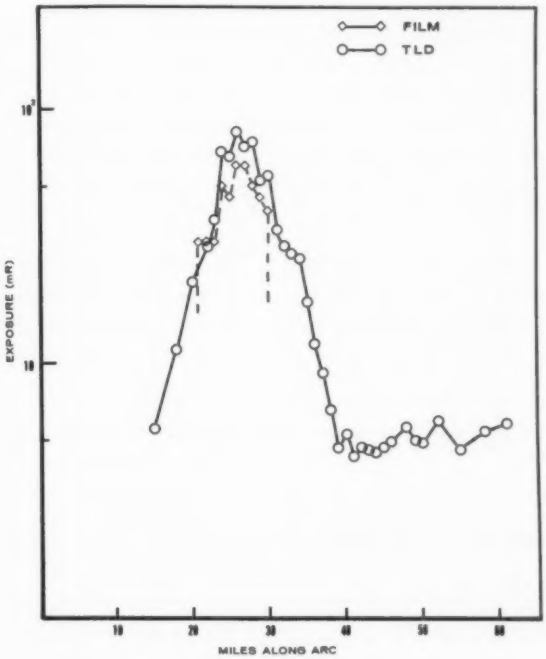

Figure 7. Cloud profile, Arc 4, Buggy 1

Table 4. Paired thermoluminescent dosimeter-film badge data from Arc 4, Buggy 1

Thermoluminescent dosimeters (mR)	Film badge (mR)
29.6	30
37.0	30
53.4	45
54.7	40
65.8	45
69.4	50
72.8	60
74.0	50
81.6	60

A linear regression on the data of table 4 yielded the relation, $y = 10.5 + 0.586x$, which is plotted in figure 8. The slope of the regression line was equal to 0.586 with a coefficient of variation of 4.37 percent and a correlation coefficient of 0.94.

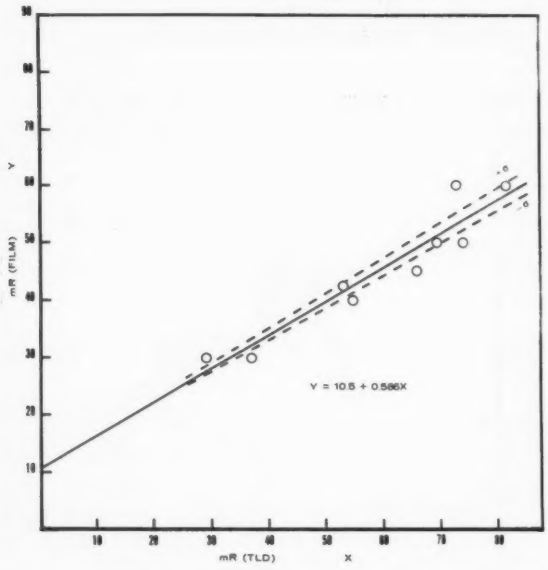

Figure 8. Correlation of film and TLD response from Arc 4, Buggy 1

The data in figures 5, 6, and 8, and their respective analyses are presented in the order of decreasing exposure levels. In general, as the level of exposures decreases, the correlation coefficient of film and TLD response decreases. The slope also decreases from unity, indicating that the range of exposure is near the minimum detectable limit of the film, i.e., there is a flattening of the curve at low exposures. An increasing degree of variation accompanies film response as exposure levels decrease, further indicating that the lower limit of detection is being approached. The above data would indicate that the lower detection limits of the 556 and 545 film are approximately 45 mR and 30 mR, respectively.

Discussion

It has been shown that the film badge as used by NERC–LV in the offsite environment is incapable of providing background information. During 1967, only 4 percent of the 6,454 badges issued had a reported value greater than zero. In addition, the data which were available varied from the expected exposures sufficiently that their validity was in doubt.

The Nuclear Engineering Company disposal site film badge data which escaped heat damage showed an excellent agreement with the TLD data. The high correlation is attributable to the ideal exposure range, 40–700 mR, for the film.

The same situation was seen in greater detail in the investigation of Plowshare data. Analyses of data resulting from three different levels of exposure indicated that as exposure levels decreased, the correlation coefficient of film and TLD response decreased. This is an indication that at lower exposures, TLD and film results are less likely to agree. It was evident that the lower exposures were approaching the minimum detectable limit of the film because the slope of the linear regressions decreased from unity with decreasing exposures.

A definite relationship between ambient temperatures and film damage has been shown in both the routine network data and Nuclear Engineering Company disposal site data. During 1967, 22 percent of the 6,454 film badges issued to routine stations were lost or damaged. The monthly damage percentage varied seasonally from a low of 1.8 percent in December to a high of 71.2 percent in July. Frequency of heat damage to film badges located at the Nuclear Engineering Company disposal site followed the same seasonal trend seen in the routine data. In 1967, 27 percent of the badges were heat damaged.

A statistical test of the Nuclear Engineering Company data indicated a possible seasonal effect on film response, in addition to the seasonal fluctuation of heat damage. This, and other research, tend to indicate that the precision of film response is less than that of the TLD.

The TLD is more suitable as an environmental monitor than the film badge and is quite

capable of providing background information. In addition, it is unaffected by environmental heating both in terms of damage and response. Of 2,461 TLD's issued to routine stations, only 10 or 0.4 percent, failed to produce usable data. No data were missing from the 132 TLD's issued to the Nuclear Engineering Company disposal site during this same year.

In addition to the results of this investigation, there are several pieces of recent supporting research. According to Johnson and Attix (*2*), most erroneous film data, including readings which occur when no exposure exits, can be related to heat and humidity damage. They compared a quartz fiber dosimeter and two types of TLD's with film badges worn by personnel. The first three dosimeters agreed within 10 percent but the film badges were often in error by a factor of two or three.

From a processing standpoint, film is subject to more variables than the TLD. The accuracy and reproducibility of reported film badge exposures by commercial dosimetry services often are quite poor (*3*). The best accuracy appeared to be −50 to +200 percent. The film processing service at Mercury, Nev., used by NERC–LV is believed to be considerably better than this (±20 percent above 100 mR). This claim is supported by the good correlation of our film and TLD data in favorable exposure ranges.

Kathren (*4*) has shown that considerable fogging of dosimetry film occurs above 50°C, a condition often attained in the field situations under discussion. This high frequency of heat and light damage was one of the major reasons for investigating and acquiring a TLD system at NERC–LV.

Conclusions

The review of TLD and film badge data from the routine dosimetry stations, the Nuclear Engineering Company disposal site, and a Plowshare experiment, leads to conclusions which favor TLD's. The TLD is more sensitive to the exposures of interest than the film badge. Because of this, it has been possible to obtain average values for background exposure rates at the various dosimetry stations.

The high ambient temperatures encountered during the summer months cause an unacceptable amount of damage to film badges used as environmental monitors. In addition to heat damage, there is evidence that film sensitivity is temperature dependent, which may cause a seasonal effect on film badge results. TLD's at the same locations sustain no apparent effects from environmental heating.

Statistical treatment of dosimetry data shows the TLD to be more precise than the film. Typical TLD reproducibility is well within ±5 percent.

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SECTION I. MILK AND FOOD

Milk Surveillance, June 1972

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

Figure 1. Milk sampling networks in the Western Hemisphere

metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conduct periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during July 1971 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. Considerable improvement has been made in the accuracy of the analyses of all radionuclides compared to the results of previous studies. Some improvement is still needed in the technique for determining the strontium-90 results. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total	
Iodine-131 (69 pCi/liter)	13 (100%)	0	0	13	6
Cesium-137 (52 pCi/liter)	12 (92%)	1 (8%)	0	13	6
Strontium-89 (31 pCi/liter)	9 (90%)	1 (10%)	0	10	6
Strontium-90 (41.6 pCi/liter)	9 (69%)	1 (8%)	3 (23%)	13	2.4

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range has also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1-5 pCi/liter for levels <50 pCi/liter; 5-10% for levels ≥50 pCi/liter;
Strontium-90	1-2 pCi/liter for levels <20 pCi/liter; 4-10% for levels ≥20 pCi/liter;
Iodine-131, Cesium-137, Barium-140	4-10 pCi/liter for levels <100 pCi/liter; 4-10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Table 2. Concentration of radionuclides in milk for June 1972 and 12-month period, July 1971 through June 1972

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:						
Ala:	Montgomery[c]	P	NA	7	15	10
Alaska:	Palmer[c]	P	5	5	15	12
Ariz:	Phoenix[c]	P	NA	0	0	0
Ark:	Little Rock[c]	P	NA	12	13	10
Calif:	Sacramento[c]	P	NA	1	0	0
	San Francisco[c]	P	NA	3	0	0
	Del Norte	P	13	11	12	10
	Fresno	P	0	2	0	5
	Humboldt	P	3	3	0	7
	Los Angeles	P	0	2	0	5
	Mendocino	P	3	5	0	7
	Sacramento	P	2	2	0	6
	San Diego	P	0	1	0	5
	Santa Clara	P	0	1	0	7
	Shasta	P	2	3	0	8
	Sonoma	P	2	2	0	7
Colo:	Denver[c]	P	NA	5	0	5
	East	R	NA		[d]0 (2)	0
	Northeast	R	NA		[d]0 (8)	1
	Northwest	R	NS		NS	0
	South Central	R	NS		NS	
	Southeast	R	NA		[d]0	0
	Southwest	R	NA		[d]0	0
	West	R	NA		[d]0	5
Conn:	Hartford[c]	P	NA	6	0	8
	Central	P	7	7	16	14
Del:	Wilmington[c]	P	NA	8	15	5
D.C:	Washington[c]	P	NA	7	0	6
Fla:	Tampa[c]	P	4	5	33	40
	Central	R	4	6	49	39
	North	R	4	10	17	21
	Northeast	R	3	6	11	35
	Southeast	R	8	6	113	59
	Tampa Bay area	P	4	6	34	38
	West	R	6	10	20	19
Ga:	Atlanta[c]	P	NA	9	12	15
Hawaii:	Honolulu[c]	P	0	3	0	3
Idaho:	Idaho Falls[c]	P	4	5	0	0
Ill:	Chicago[c]	P	7	7	0	11
Ind:	Indianapolis[c]	P	NA	7	0	3
	Central	P	6	7	15	12
	Northeast	P	5	7	15	14
	Northwest	P	8	8	15	16
	Southeast	P	9	8	25	15
	Southwest	P	9	8	10	15
Iowa:	Des Moines[c]	P	NA	4	0	1
	Iowa City	P	6	6	10 (3)	10
	Des Moines	P	7	7	11	11
	Little Cedar	P	6	7	NS	11
	Spencer	P	NS	6	NS	11
Kans:	Wichita[c]	P	NA	8	0	2
	Coffeyville	P	8	8	0	13
	Dodge City	P	7	5	0	9
	Falls City, Nebr	P	NS		NS	
	Hays	P	9	10	0	9
	Kansas City	P	7	8	0	11
	Topeka	P	6	8	11	9
	Wichita	P	7	11	0	9
Ky:	Louisville[c]	P	NA	8	12	9
La:	New Orleans[c]	P	10	14	0	12
Maine:	Portland[c]	P	NA	7	22	21
Md:	Baltimore[c]	P	NA	8	0	5
Mass:	Boston[c]	P	6	7	14	11
Mich:	Detroit[c]	P	NA	7	13	11
	Grand Rapids[c]	P	NA	8	0	8
	Bay City	P	3	5	0	13
	Charlevoix	P	6	9	9 (5)	14
	Detroit	P	4	6	0	10
	Grand Rapids	P	3	5	16	9
	Lansing	P	6	7	0 (2)	14
	Marquette	P	5	7	23 (2)	24
	Monroe	P	0	3	14	5
	South Haven	P	3	5	8 (5)	9
Minn:	Minneapolis[c]	P	NA	8	14	16
	Bemidji	P	5	8	14	19
	Duluth	P	13	15	34	29
	Fergus Falls	P	8	8	12	17
	Little Falls	P	22	16	51	31
	Mankato	P	7	6	0	12
	Marshall	P	4	6	11	12

See footnotes at end of table.

Table 2. Concentration of radionuclides in milk for June 1972 and 12-month period, July 1971 through June 1972—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:						
Minn:	Minneapolis	P	10	12	17	17
	Rochester	P	7	7	11	14
Miss:	Jackson[c]	P	NA	12	14	10
Mo:	Kansas City[c]	P	NA	8	0	5
	St. Louis[c]	P	NA	5	0	4
Mont:	Helena[c]	P	NA	6	0	7
Nebr:	Omaha[c]	P	NA	7	0	3
Nev:	Las Vegas[c]	P	NA	2	0	1
N.H:	Manchester[c]	P	NA	8	23	18
N.J:	Trenton[c]	P	NA	7	0	6
N.Mex:	Albuquerque[c]	P	NA	3	0	0
N.Y:	Buffalo[c]	P	5	6	0	8
	New York City[c]	P	NA	7	0	9
	Syracuse[c]	P	NA	7	0	9
	Albany	P	6	6	[d]0 (5)	[d]0
	Buffalo	P	6	4	[d]0	[d]0
	Massena	P	9	7	[d]0 (2)	[d]0
	New York City	P	10	7	[d]0	[d]0
	Syracuse	P	6	5	[d]0	[d]0
N.C:	Charlotte[c]	P	NA	11	0	9
N. Dak:	Minot[c]	P	NA	9	0	14
Ohio:	Cincinnati[c]	P	NA	6	0	4
	Cleveland[c]	P	NA	7	0	7
Okla:	Oklahoma City[c]	P	NA	7	0	7
Oreg:	Portland[c]	P	4	5	0	4
	Baker	P	NA		[d]0	[d]0
	Coos Bay	P	NA		[d]0	[d]3
	Eugene	P	NA		[d]0	[d]1
	Medford	P	NA		[d]0	[d]4
	Portland composite	P	NA		[d]0	[d]7
	Portland local	P	NA		[d]0	[d]11
	Redmond	P	NA		[d]0	[d]0
	Tillamook	P	NA		17	[d]12
Pa:	Philadelphia[c]	P	NA	7	11	6
	Pittsburgh[c]	P	NA	10	0	6
	Dauphin	P	6	7	0	12
	Erie	P	4	7	0	12
	Philadelphia	P	7	5	16	13
	Pittsburgh	P	9	6	0	14
R.I:	Providence[c]	P	NA	8	15	11
S.C:	Charleston[c]	P	9	9	23	15
S.Dak:	Rapid City[c]	P	NA	6	0	7
Tenn:	Chattanooga[c]	P	NA	8	0	9
	Memphis[c]	P	NA	7	0	4
	Chattanooga	P	NA	10	17	12
	Clinton	R	NA	9	11 (2)	14
	Fayetteville	R	NA	9	14	6
	Kingston	R	NA	9	12 (2)	10
	Knoxville	P	NA	8	14 (2)	9
	Lawrenceburg	R	NA	8	0	0
	Nashville	P	NA	8	16	8
	Pulaski	R	NA	8	18 (2)	8
Tex:	Austin[c]	P	NA	1	0	0
	Dallas[c]	P	NA	6	0	1
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	
Utah:	Salt Lake City[c]	P	5	4	0	5
Vt:	Burlington[c]	P	NA	5	0	11
Va:	Norfolk[c]	P	NA	8	12	7
Wash:	Seattle[c]	P	NA	4	0	6
	Spokane[c]	P	NA	6	0	8
	Benton County	R	NS	1	NS	0
	Franklin County	R	0	1	0	2
	Longview	R	7		0	
	Sandpoint, Idaho	R	13	12	0	20
	Skagit County	R	12	8	0	6
W. Va:	Charleston[c]	P	NA	8	14	5
Wisc:	Milwaukee[c]	P	NA	6	13	7
Wyo:	Laramie[c]	P	NA	3	0	2

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for June 1972 and 12-month period, July 1971 through June 1972—continued

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA:					
Alberta: Calgary	P	7	7	14	18
Edmonton	P	7	7	NA	
British Columbia: Vancouver	P	8	9	30	25
Manitoba: Winnipeg	P	6	7	14	22
New Brunswick: Fredericton	P	12	12	15	20
Newfoundland: St. John's	P	17	18	30	30
Nova Scotia: Halifax	P	9	11	11	23
Ontario: Ottawa	P	7	7	12	12
Sault Ste. Marie	P	12	13	23	30
Thunder Bay	P	10	12	18	25
Toronto	P	3	4	10	12
Windsor	P	4	4	6	9
Quebec: Montreal	P	7	7	10	16
Quebec	P	8	10	20	28
Saskatchewan: Regina	P	7	7	11	17
Saskatoon	P	7	9	15	18
CENTRAL AND SOUTH AMERICA:					
Canal Zone: Cristobal[c]	P	NA	0	16	7
Chile: Santiago	P	0	0	0	2
Colombia: Bogota	P	2	1	0	0
Ecuador: Guayaquil	P	0	0	0	0
Jamaica: Montego Bay	P	5	4	102	69
Puerto Rico: San Juan[c]	P	NA	3	12	8
Venezuela: Caracas	P	NS		NS	
PMN network average [e]		5	6	6	8

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0 was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:
Cesium-137: Colorado—25 pCi/liter Strontium-90: New York—3 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

[e] This entry gives the average radionuclides concentrations for the Pasteurized Milk Network stations denoted by footnote[c].
NA, no analysis.
NS, no sample collected.

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiation Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12

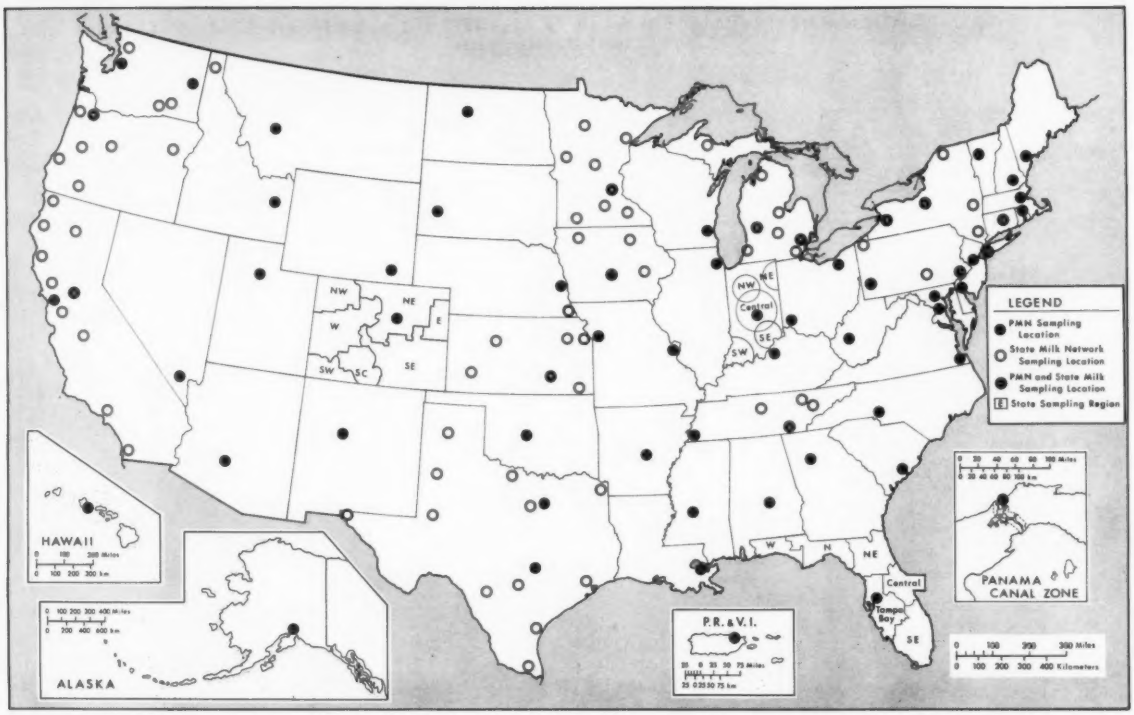

Figure 2. State and PMN milk sampling stations in the United States

monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for June 1972 and the 12-month period, July 1971 to June 1972. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for June 1972 were below the respective practical reporting levels. Table 3 gives monthly averages for those stations at which strontium-89, iodine-131, and barium-140 were detected.

Table 3. Strontium-89, iodine-131, and barium-140 in milk, June 1972

Sampling location		Concentration (pCi/liter)		
		Strontium-89	Iodine-131	Barium-140
Calif:	Del Norte (State)	10		
Kans:	Coffeyville (State)	6		
	Dodge City (State)	6		
	Hays (State)	5		
	Kansas City (State)	6		
	Topeka (State)	6	13	11
	Wichita (State)	9		
La:	New Orleans (PMN)	9		

Strontium-90 monthly averages ranged from 0 to 22 pCi/liter in the United States for June 1972, and the highest 12-month average was 16 pCi/liter (Little Falls, Minn.) representing 8.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 113 pCi/liter in the United States for June 1972, and the highest 12-month average was 59 pCi/liter (Southeast Florida) representing 1.6 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*7*) and Jamaica.

Acknowledgement

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Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	July-December 1970	November 1971
Carbon-14 in Total Diet and Milk	July-December 1971	May 1972
Connecticut Standard Diet	January-December 1970	December 1971
Institutional Total Diet	October-December 1971 and 1971 Annual Summary	June 1972
Radiostrontium in Milk	January-December 1970	April 1972
Strontium-90 in Tri-City Diets	January-December 1970	November 1971

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence [1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	January-December 1970	December 1971
Minnesota	January-June 1970	November 1971
New York	July-December 1970 and January-June 1971	May 1972
North Carolina	1968-1970	September 1972
Radioactivity in California Waters	January-December 1970	June 1972
Radioactivity in Florida Waters	1969	January 1972
Radiostrontium in Tap Water, *HASL*	January-June 1971	April 1972
Tritium in Community Water Supplies	1969	December 1970
Tritium Surveillance System	January-March 1972	August 1972
Washington	July 1969-June 1970	March 1972

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Gross Radioactivity in Surface Waters of the United States February 1972

Office of Water Programs
U.S. Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1957 as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the U.S. Environmental Protection Agency, Office of Water Programs. Regional offices of the Environmental Protection Agency are responsible for the collection of samples and the entering of the resulting data into the analytical storage and retrieval system. Radioactivity analyses are performed in the centralized radioactivity laboratories of the Office of Water Programs (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for October 1968 (April 1969 issue). With the publication of data for January 1971, it is intended to reinitiate this activity as a monthly report series. The unpublished data for the time interval of November 1968 through December 1970 will be the subject of a future summary article.

Table 1 presents the gross alpha and beta results for samples collected from 12 rivers during February 1972. Table 2 presents additional gross radioactivity measurements collected from six river stations during October 1971. These data supplement the data previously pub-

Table 1. Gross radioactivity in U.S. surface waters, February 1972

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Bear River:					
Idaho-Utah Line	1	1.7	4.2	5	12
Clinch River:					
Kingston, Tenn	[a]4	<0.4 (<0.3, 0.4)	<0.5 (<0.4–0.6)	<2 (<2, 2)	<4 (<3, 5)
Colorado River:					
DeBeque, Colo:	1	<.4	6.3	<2	14
Highway Bridge, Moab, Utah	3	1.4 (.5, 1.9)	7.8 (6.7, 9.7)	4 (2, 6)	15 (12, 19)
Millcreek above Moab, Utah	4	.9 (.8, 1.0)	10.1 (8.8, 11.9)	6 (4, 8)	18 (17, 20)
Silt, Colo	1	<.4	<1.7	4	11
Colorado-Utah Line	1	1.1	3.6	10	13
Dolores River:					
Bedrock, Colo	3	6.7 (1.7, 15.9)	8.1 (2.9, 11.4)	27 (7, 51)	19 (11, 28)
Gateway, Colo	4	1.7 (1.2, 2.1)	23.8 (18.7, 38.2)	6 (5, 8)	63 (37, 98)
Gunnison River:					
Grand Junction, Colo	1	.7	6.0	3	8
Mississippi River:					
Burlington, Iowa	1	1.4	2.3	5	5
Missouri River:					
St. Joreph, Mo	1	.6	4.8	3	13
St. Louis, Mo	1	1.2	4.8	3	15
Ohio River:					
Cincinnati, Ohio	4	1.8 (.5, 4.1)	<.7 (.6, .8)	6.8 (<2, 12)	7 (3, 17)
Roanoke River:					
John Kerr Dam, Va	4	.7 (.4, 1.0)	<.5 (<.4, .6)	<2 (<2, 3)	2 (2, 3)
San Miguel River:					
Naturita, Colo	4	1.0 (<.4, 2.4)	3.3 (1.9, 4.7)	4 (<2, 9)	7 (<5, 8)
Uravan, Colo	4	<.6 (<.4, 1.0)	3.8 (2.3, 7.7)	<3 (<2, 4)	<9 (<4, 13)
Below Uravan, Colo	4	1.0 (.4, 1.6)	27.4 (11.5, 34.2)	6 (<2, 9)	39 (21, 48)
St. Lawrence River:					
Massena, N.Y	3	<.4 (< .3, .4)	<1.0 (< .6–1.5)	<2 (<2, <2)	5 (4, 6)
Yampa River:					
Maybell, Colo	1	1.5	1.7	11	9

[a] Where more than one sample is analyzed during the month, the minimum and maximum are in parentheses.

Table 2. Gross radioactivity in U.S. surface waters, October 1971

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Arkansas River:					
Ponca City, Okla.	1	5.7	5.3	19	11
Mississippi River:					
Vicksburg, Miss.	1	1.8	<0.4	6	4
West Memphis, Ark.	1	.8	2.3	3	9
Red River:					
Dennison, Tex.	1	.6	3.6	<2	8
Rio Grande:					
Brownsville, Tex.	1	1.4	6.3	4	22
Laredo, Tex.	1	2.3	4.4	5	10
Saline River:					
Ruliff, Tex.	1	1.0	.7	4	6
Verdigris River:					
Nowata, Okla.	1	1.5	<1.1	5	5

lished in *Radiation Data and Reports*, Volume 13, June 1972. The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition of *Standard Methods for the Examination of Water and Wastewater* (*1*). Results are reported for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*2*), and is calculated to be <0.2 pCi/liter for gross alpha radioactivity and <1 pCi/liter for gross beta radioactivity measurements.

REFERENCES

(*1*) AMERICAN PUBLIC HEALTH ASSOCIATION: AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater, 13th Edition, New York, N.Y. (1971).

(*2*) U.S. DEPARTMENT OF COMMERCE. Radioactivity, Recommendations of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 86 (November 29, 1963).

Radioactivity of Lake Michigan, August-September 1970

Office of Water Programs
U.S. Environmental Protection Agency

In accordance with recommendations of the Conferees of the Four-State Conference on Pollution of Lake Michigan and Its Tributary Basin (Illinois, Indiana, Michigan, and Wisconsin), a committee was appointed to develop specific recommendations for a coordinated Four-State-Federal monitoring program in the Lake Michigan Basin.

It was recommended by the Monitoring Committee that the Federal government monitor the open waters of Lake Michigan at specified stations, during the spring, summer, and fall of each year. At stations in unstratified areas, samples are to be collected at the surface, at mid-depth, and near the lake bottom. In stratified areas, samples are to be collected at the surface, just above and below the thermocline, and near the bottom.

The Region V Office of the Environmental Protection Agency is responsible for the overall conduct of the program. The radioactivity monitoring aspect of the program was initiated in August 1970, extending through September 1970. Water and sediment samples were collected and sent for radiochemical analyses to the Engineering and Sciences Branch of the

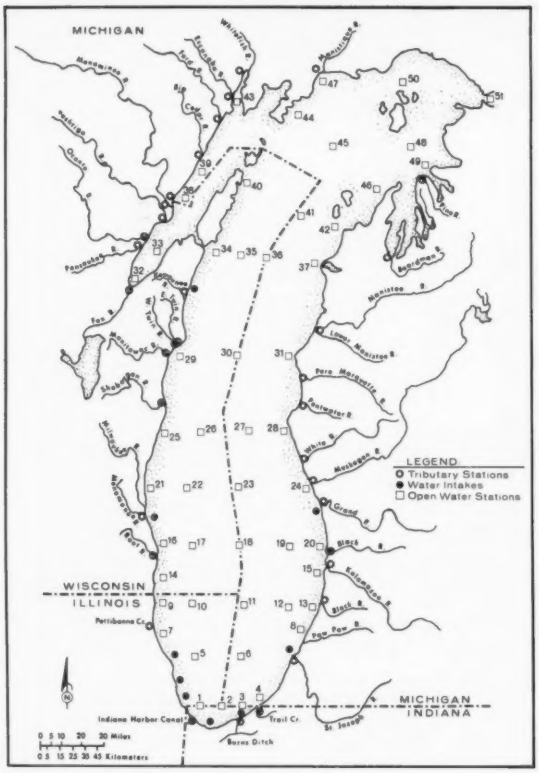

Figure 1. Lake Michigan basin monitoring stations

Table 1. Lake Michigan basin water monitoring stations

Station	Latitude	Longitude
1	41°46′00″	87°20′00″
2	41°46′00″	87°13′00″
3	41°46′00″	87°00′00″
4	41°48′00″	86°53′00″
5	42°00′00″	87°25′00″
6	42°00′00″	87°00′00″
7	42°12′00″	87°43′00″
8	42°14′00″	86°28′00″
9	42°24′00″	87°47′00″
10	42°23′00″	87°25′00″
11	42°23′00″	87°00′00″
12	42°23′00″	86°35′00″
13	42°23′00″	86°20′00″
14	42°37′00″	87°45′00″
15	42°37′00″	86°18′00″
16	42°47′00″	87°41′00″
17	42°44′00″	87°25′00″
18	42°44′00″	87°00′00″
19	42°44′00″	86°35′00″
20	42°44′00″	86°15′00″
21	43°08′00″	87°53′00″
22	43°08′00″	87°25′00″
23	43°08′00″	87°00′00″
24	43°08′00″	86°19′00″
25	43°36′00″	87°44′00″
26	43°36′00″	87°22′00″
27	43°36′00″	86°47′00″
28	43°36′00″	86°33′00″
29	44°05′00″	87°34′00″
30	44°05′00″	87°00′00″
31	44°05′00″	86°33′00″
32	44°35′35″	87°57′19″
33	44°50′20″	87°45′55″
34	44°47′00″	87°14′00″
35	44°45′00″	87°00′00″
36	44°43′00″	86°44′00″
37	44°30′00″	86°17′00″
38	45°05′00″	87°31′00″
39	45°23′30″	87°16′20″
40	45°14′00″	86°53′00″
41	45°02′00″	86°24′00″
42	44°56′00″	86°05′00″
43	45°45′38″	87°02′45″
44	45°34′00″	86°21′00″
45	45°32′00″	86°10′00″
46	45°13′00″	85°40′00″
47	45°56′00″	86°14′00″
48	45°31′00″	85°25′00″
49	45°21′00″	85°20′00″
50	45°53′00″	85°36′00″
51	45°48′00″	84°45′00″

Division of Applied Technology in Cincinnati, Ohio.

Sampling stations for radioactivity monitoring are shown in figure 1. Table 1 presents the specific latitude-longitude coordinates for these stations. Table 2 presents the gross alpha and gross beta measurements, tritium levels and solids concentration. Selected samples were composited using equal aliquots for strontium-90 and cesium-137 measurements. Table 3 presents these results. Table 4 presents the radioactivity data associated with the bottom sediments. In all cases, the error term is the counting error only and is expressed at the 1-sigma level. Radioactivity concentrations noted as "less than" are defined by NBS Handbook 86 (*1*). The data show the levels of radioactivity are very low and, in most cases, are less than the sensitivity of the analytical methods and counting equipment.

REFERENCE

(*1*) U.S. DEPARTMENT OF COMMERCE. Radioactivity, Recommendations of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 86 (November 29, 1963).

Table 2. Radioactivity in Lake Michigan water, August–September 1970

Station	Source	Date collected (1970)	Suspended solids			Dissolved solids			Tritium (nCi/liter)
			mg/liter	Alpha (pCi/liter)	Beta (pCi/liter)	mg/liter	Alpha (pCi/liter)	Beta (pCi/liter)	
51	Surface	8/4	<0.1	<0.2	<1.8	132	<0.5	4.1±1.2	<0.4
51	Mid depth		.4	<.2	<1.8	144	<.5	<3.1	.9± .2
51	Bottom		5.7	<.3	<2.5	80	<.3	<1.8	.5± .2
50	Surface		<.1	<.2	<1.8	128	<.4	<2.4	<.4
50	Mid depth		.4	<.2	<1.6	124	<.4	<2.7	<.4
50	Bottom		.7	<.2	<1.8	108	<.4	<2.4	<.4
47	Surface	8/5	.5	<.2	<1.7	132	<.4	<2.8	<.4
47	Mid depth		.4	<.2	<1.6	104	<.4	<2.2	.8± .2
47	Bottom		.7	<.2	<1.8	124	<.4	<2.7	<.4
48	Surface		<.1	<.2	<1.6	144	<.5	<3.1	.5± .2
48	Above thermocline		.8	<.2	<1.7	120	<.4	<2.6	<.4
48	Below thermocline		.7	<.2	<1.8	112	<.4	<2.5	<.4
48	Bottom		1.9	<.2	<1.7	116	<.4	<2.5	<.4
44	Surface	8/6	<.1	<.2	<1.8	244	<.8	<5.3	.7± .2
44	Above thermocline		.2	<.2	<1.8	248	<.6	6.5±1.5	.6± .2
44	Below thermocline		.1	<.2	<2.2	248	<.6	5.3±1.5	<.4
44	Bottom		.2	<.2	<1.6	236	<.6	6.7±1.4	.5± .2
40	Surface	8/7	<.1	<.2	<1.7	80	<.2	2.7± .5	.9± .2
40	Mid depth		<.1	<.2	1.7	88	<.2	3.0± .5	.6± .2
40	Bottom		.4	<.2	<1.7	88	<.2	2.8± .5	.5± .2
34	Surface	8/8	<.1	<.2	<2.4	92	<.2	2.8± .5	.8± .2
34	Mid depth		.7	<.1	<1.1	132	<.3	2.5± .8	<.4
34	Bottom		.5	<.1	<1.1	124	<.3	3.4± .7	.5± .2
29	Surface		.2	<.1	<1.2	148	<.4	3.1± .9	.9± .2
29	Mid depth		.9	<.1	1.2± .5	128	<.3	4.6± .8	.7± .2
29	Bottom		.9	<.1	<1.1	140	<.3	4.6± .8	.6± .2
30	Surface	8/10	<.1	<.1	<1.2	124	<.3	4.1± .7	.8± .2
30	Above thermocline		.2	<.1	1.2	136	<.3	3.6± .8	.5± .2
30	Below thermocline		.2	<.1	<.8	128	<.3	3.4± .8	.4± .2
30	Bottom		.7	<.1	<1.2	164	<.4	4.2±1.0	.6± .2
31	Surface	8/11	.5	<.1	1.4± .4	160	<.4	5.0±1.0	<.4
31	Mid depth		.3	<.1	<1.3	168	<.4	<2.5	<.4
31	Bottom		.7	<.1	<1.2	136	<.3	2.8± .8	.6± .2
37	Surface	8/12	<.1	<.1	<1.2	140	<.3	3.1± .8	.5± .2
37	Above thermocline		<.1	<.1	<1.1	148	<.4	3.4± .9	<.4
37	Below thermocline		<.1	<.1	<1.1	144	<.4	<2.1	<.4
37	Bottom		.2	<.1	<1.2	144	<.3	3.8± .7	<.4
41	Surface		.9	<.1	<1.2	148	.4± .2	5.1± .7	6± .2
41	Above thermocline		<.1	<.1	<1.2	132	<.3	3.6± .6	<.4
41	Below thermocline		<.1	<.1	<1.2	132	<.3	1.7± .6	.5± .2
41	Bottom		<.1	<.1	<1.2	148	<.3	3.7± .7	.9± .2
42	Surface	8/13	.3	<.1	<.1	152	.3± .2	5.4± .7	.6± .1
42	Mid depth		.2	<.1	<.9	152	<.3	4.1± .7	<.3
42	Bottom		.4	<.1	<.9	160	.5± .2	4.6± .8	.4± .2
49	Surface		.2	<.1	<.9	136	<.3	3.5± .6	.8± .2
49	Above thermocline		.2	<.1	<1.0	144	<.3	4.1± .7	.6± .2
49	Below thermocline		.2	<.1	<.9	144	<.3	4.3± .7	.6± .2
49	Bottom		.7	<.1	<.9	160	<.3	2.5± .7	.6± .2
1	Surface	9/16	.5	<.1	<.7	160	<.3	3.7± .8	.4± .2
1	Mid depth		.1	<.1	<.7	164	<.3	3.9± .8	.8± .2
1	Bottom		<.1	<.1	<.7	268	<.5	5.9±1.3	.9± .2
3	Surface	9/17	<.1	<.1	<.8	204	<.4	6.1±1.2	.8± .2
3	Above thermocline		<.1	<.1	.8±.3	204	.6± .3	5.3±1.2	<.4
3	Bottom		<.1	<.1	<.9	192	<.4	3.9±1.1	<.4
4	Surface		<.1	<.1	<.8	184	<.4	5.4±1.0	.7± .2
4	Mid depth		<.1	<.1	<.9	164	.3± .2	3.9± .9	.8± .2
4	Bottom		9.3	<.1	<.8	184	<.4	3.9±1.0	.4± .2
5	Surface	9/16	.1	<.1	<.8	204	<.4	3.7±1.1	.6± .2
5	Above thermocline		<.1	<.1	<.9	196	<.4	3.8±1.1	<.4
5	Below thermocline		<.1	<.1	<.9	96	<.2	2.5± .8	.4± .2
5	Bottom		<.1	<.1	<.9	96	<.2	2.4± .8	<.4
2	Surface	9/16	4.3	<.1	<.8	100	<.2	2.4± .8	.7± .2
2	Mid depth		<.1	<.1	<.9	72	<.1	<1.5	.5± .2
2	Bottom		.1	<.1	<.1	128	<.2	<2.6	<.4
6	Surface	9/17	<.1	<.1	<1.2	148	<.2	<3.0	<.4
6	Above thermocline		<.1	<.1	<1.0	148	<.2	<3.0	<.4
6	Below thermocline		<.1	<.1	<1.0	160	<.3	3.7±1.3	<.4
6	Bottom		.2	<.1	<1.1	152	<.3	3.5±1.2	<.4
8	Surface		1.1	<.1	<2.3	148	<.3	<3.0	.6± .2
8	Below thermocline		.1	<.1	<1.1	148	<.3	<3.0	.4± .2
8	Bottom		.4	<.1	<1.1	88	<.2	2.0± .7	.5± .2
7	Surface	9/18	.1	<.1	<1.1	76	<.2	2.2± .6	<.4
7	Above thermocline		2.8	<.1	<1.7	124	<.3	<2.5	.5± .2
7	Bottom		1.8	<.1	<1.2	108	<.3	<2.2	<.4
9	Surface		1.0	<.1	<1.1	92	<.2	<1.9	<.4
9	Mid depth		.4	<.1	<1.1	312	<.7	<6.4	.7± .2
9	Bottom		.5	<.1	<1.1	276	<.6	<5.7	.6± .2
14	Surface	9/21	.4	<.1	<1.1	216	<.5	4.7±1.8	.7± .2
14	Mid depth		.6	<.1	<1.1	176	<.4	<3.6	.4± .2
14	Bottom		.6	<.1	<1.1	176	<.4	<3.6	<.4
16	Surface		.5	<.1	<1.1	456	<1.1	<9.4	.5± .2
16	Mid depth	9/21	.3	<.1	<1.1	124	.2± .1	3.2±1.0	.4± .2
16	Bottom		.4	<.1	1.2± .5	112	.2± .1	2.5±1.0	.6± .2
17	Surface		.5	<.1	1.3± .5	136	<.2	<2.9	<.4
17	Above thermocline		.4	<.1	<1.8	156	<.2	5.0±1.3	.8± .2
17	Below thermocline		.3	<.1	<1.2	160	<.2	3.9±1.4	.4± .2
17	Bottom		.2	<.1	<1.1	152	.3± .1	3.9±1.3	<.4

See footnotes at end of table.

Table 2. Radioactivity in Lake Michigan water, August–September 1970—continued

Station	Source	Date collected (1970)	Suspended solids			Dissolved solids			Tritium (nCi/liter)
			mg/liter	Alpha (pCi/liter)	Beta (pCi/liter)	mg/liter	Alpha (pCi/liter)	Beta (pCi/liter)	
41	Surface	9/22	<.1	<.1	<1.2	108	.1± .1	<2.3	<.4
41	Above thermocline		<.1	<.1	<1.2	140	<.2	<3.0	<.4
41	Below thermocline		<.1	<.1	<1.1	100	<.1	2.6± .8	<.4
41	Bottom		72.4	.3±.1	6.3± .5	120	.2± .1	3.2±1.0	<.4
36	Surface		.1	<.1	<1.1	92	<.1	<1.9	<.4
36	Above thermocline		<.1	<.1	<1.2	92	<.1	2.1± .8	.7± .2
36	Below thermocline		<.1	<.1	<1.1	264	<.5	<5.6	<.4
36	Bottom		<.1	<.1	<1.1	272	.9± .3	<5.8	<.4
35	Surface		.1	<.1	<1.1	200	<.4	<4.2	<.4
35	Above thermocline		<.1	<.1	<1.2	204	<.4	<4.3	.5± .2
35	Below thermocline		<.1	<.1	<1.3	72	<.2	1.3± .4	<.4
35	Bottom		<.1	<.1	<1.2	92	<.2	2.0± .6	<.4
34	Surface	9/24	.2	<.1	<1.2	112	<.3	2.5± .7	<.4
34	Above thermocline		.4	<.1	<1.2	108	<.3	3.4± .7	<.4
34	Bottom		.5	<.1	<.9	172	<.4	4.7±1.0	.6± .2
39	Mid depth	9/23	.5	<.1	<.8	172	<.4	5.3±1.0	<.4
39	Bottom		.4	<.1	<.8	176	<.4	2.9±1.0	<.4
43	Surface		2.3	<.1	<.8	180	.6± .3	4.9±1.1	<.4
43	Mid depth		1.3	<.1	<.8	140	<.4	<2.1	<.4
43	Bottom		30.9	.4± .1	4.1± .3	144	<.4	4.7± .9	<.4
40	Surface	9/24	.7	<.1	<.8	132	<.3	3.3± .8	<.4
40	Below thermocline		.1	<.1	<1.0	132	<.3	4.4± .8	<.4
40	Bottom		.7	<.1	<.9	160	<.4	3.3±1.0	<.4
33	Surface	9/23	.7	<.1	<.8	236	<.6	3.9±1.4	.6± .2
33	Mid depth		.0	<.1	<.8	184	<.5	5.0±1.1	<.4
33	Bottom		48.8	.4± .1	4.5± .4	164	<.4	4.1±1.0	<.4
29	Surface	9/26	.6	<.1	<.9	148	<.4	4.9± .9	.4± .2
29	Above thermocline		.4	<.1	<.8	172	<.4	3.4±1.0	.6± .2
29	Bottom		.3	<.1	<.8	168	<.6	4.3±1.0	<.4
30	Surface		.4	<.2	<1.3	140	<.5	4.2± .9	.6± .2
30	Above thermocline		.5	<.1	<.8	124	<.4	2.0± .7	.5± .2
30	Below thermocline		.3	<.1	<.8	120	<.4	3.5± .7	.4± .2
30	Bottom		.4	<.1	<.8	116	<.4	3.9± .7	<.4
38	Surface	9/23	1.0	<.1	<.8	112	<.4	2.7± .7	<.4
38	Mid depth		.8	<.1	<.8	344	.6± .3	11.5±1.7	.8± .2
38	Bottom		.8	<.1	<1.0	376	<.5	14.4±1.9	.9± .2
25	Surface	9/27	.1	<.1	<.1	292	<.5	9.1±1.4	.4± .2
25	Above thermocline		.3	<.1	<.7	252	<.4	8.6±1.2	<.4
25	Bottom		.5	.6± .1	.9± .3	360	.7± .4	11.4±1.8	.9± .2
26	Surface		<.1	<.1	<.7	304	<.5	8.4±1.5	<.4
26	Above thermocline		.5	.1± .1	<.6	244	<.4	7.1±1.2	<.4
26	Below thermocline		<.1	<.1	<.7	212	.4± .2	6.4±1.0	<.4
26	Bottom		.4	<.1	<.7	176	<.3	3.7± .9	<.4
27	Surface		.3	<.1	<.7	164	<.3	2.9± .8	.6± .2
27	Above thermocline		.5	<.1	<.7	160	<.3	3.6± .8	<.4
27	Below thermocline		.7	<.1	<.7	188	<.3	3.7± .9	<.4
27	Bottom		17.3	.1± .1	1.0± .3	192	<.3	3.4± .9	<.4
28	Surface		.2	<.1	<.6	168	<.3	2.3± .8	<.4
28	Above thermocline		.6	<.1	<.7	152	<.3	2.5± .7	<.4
28	Bottom		1.0	<.1	<.7	148	.5± .2	3.9± .7	<.4

Table 3. Radioactivity of composited water samples

Composite	Station	Source	Concentration (pCi/liter)	
			Cesium-137	Strontium-90
A	51	Surface		
	51	Mid depth	0.20±0.05	1.00±0.08
	51	Bottom		
B	50	Surface		
	50	Mid depth		
	50	Bottom	.78± .14	1.5 ± .2
	47	Surface		
	47	Mid depth		
	47	Bottom		
C	40			
	41			
	42	Surface	.10± .03	—
	41			
	40			
D	40	Mid depth		
	41	Below thermocline	<.08	.35± .05
	42	Mid depth		
	41	Below thermocline		
	40	Below thermocline		

Table 3. Radioactivity of composited water samples—continued

Composite	Station	Source	Concentration (pCi/liter)	
			Cesium-137	Strontium-90
E	40 41 42 41 40	Bottom	<.33	1.8 ± .2
F	34 37 36 35 34	Surface	<.42	1.2 ± .2
G	34 37 36 35 34	Mid depth Below thermocline Below thermocline Below thermocline Above thermocline	.53±.14	1.1 ± .1
H	36 35 34	Bottom	.41±.08	1.2 ± .1
J	29 30 31 29 30	Surface	.20± .04	.80± .08
K	29 30 31 29 30	Above thermocline Below thermocline Mid depth Above thermocline Below thermocline	<.28	2.3 ± .8
L	29 30 31 29 30	Bottom	<.30	1.4 ± .2
M	25 26 27 28	Surface	.30± .07	—
N	25 26 27 28	Above thermocline Below thermocline Below thermocline Above thermocline	<.25	—
O	25 26 27 28	Bottom	.22± .06	—
P	5 6	Surface	<.50	1.3 ± .2
Q	5 6	Below thermocline	<.33	—
S	1 3 4 2	Surface	.73±.10	.9 ±.1
T	1 3 4 2	Mid depth Above thermocline Mid depth Mid depth	.5 ± .1	1.5 ± .1
U	1 3 4 2	Bottom	.24± .05	1.4 ± .1
V	33 38	Surface	<.36	1.9 ± .2
W	39 33 38	Mid depth	.31± .08	1.1 ± .1
X	39 33 38	Bottom	.51± .14	1.2 ± .1
Y	49 49 49	Surface Below thermocline Bottom	.54± .06	.67± .06

Table 4. Radioactivity in Lake Michigan sediments, August–September 1970

Station number	Date collected (1970)	Gross alpha (pCi/g dry weight)	Gross beta (pCi/g dry weight)	*K+ (mg/g)	Natural uranium (μg/g)	Natural thorium (μg/g)	Radium-226 (pCi/g dry weight)
51	8/4	2	15	10.0	<0.1	<2	0.22
50		<1	14	8.9	<.1	<2	.24
47	8/5	<1	17	13.0	<.1	<2	.14
48		6	52	22.0	.4	2	.88
44	8/6	10	37	11.6	<.1	<2	.99
34	8/8	<1	<10	8.2	<.1	<2	.10
29		2	15	12.5	<.1	<2	.44
30	8/10	5	26	19.5	<.1	<2	.77
31	8/11	2	20	15.5	<.1	<2	<.05
37	8/12	9	38	22.0	<.1	<2	1.30
41		3	28	23.5	<.1	<2	1.23
49	8/13	3	17	11.0	<.1	<2	.43
3	9/17	3	25	12.5	.2	<2	.55
4		3	13	12.0	.1	<2	.29
5	9/16	4	33	10.9	<.1	<2	.29
6	9/17	7	37	15.5	.3	<2	.85
8		2	16	10.2	<.1	<2	.45
9	9/21	7	31	10.5	.1	<2	.29

* Potassium-40 contribution can be calculated by multiplying mg/g by 0.84 pCi/mg K+.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican National Institute of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January-December 1970	December 1971
Mexican Air Monitoring Program	January-April 1972	September 1972
Plutonium in Airborne Particulates	October-December 1971	July 1972
Surface Air Sampling Program; 80th Meridian Network, *HASL*	January-December 1969	February 1972

1. Radiation Alert Network June 1972

Division of Atmospheric Surveillance
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during June 1972.

All other field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, June 1972

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Number of samples	Total depth (mm)	Precipitation		
								Field estimation of deposition		
			Maximum	Minimum	Average[a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	19	2	0	1	3	41	3	41	25
Alaska:	Anchorage	3	0	0	0	0				
	Attu Island	22	0	0	0	0				
	Fairbanks	0				0				
	Juneau	0				0				
	Kodiak	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	19	7	1	3	0				
Ark:	Little Rock	20	3	0	1	0				
Calif:	Berkeley	20	1	0	0	1	7	1	7	0
	Los Angeles	21	1	0	1	0				
C.Z:	Ancon	17	0	0	0	0				
Colo:	Denver	21	6	1	2	4	79	[b]		
Conn:	Hartford	21	1	0	0	12	201	12	201	0
Del:	Dover	22	1	0	0	0				
D.C:	Washington	24	1	0	0	0				
Fla:	Jacksonville	22	1	0	0	6	102	6	102	20
	Miami	0				0				
Ga:	Atlanta	19	2	1	1	0				
Gaum:	Agana	0				0				
Hawaii:	Honolulu	17	1	0	0	2	15	[b]		
Idaho:	Boise	20	2	0	1	1	11	1	11	7
Ill:	Springfield	9	5	1	2	0				
Ind:	Indianapolis	20	2	0	1	0				
Iowa:	Iowa City	22	4	1	1	7	105	7	105	0
Kans:	Topeka	22	6	1	2	3	30	3	30	0
Ky:	Frankfort	8	3	1	1	0		[b]		
La:	New Orleans	18	0	0	0	4	7			
Maine:	Augusta	20	5	0	1	8	129	8	129	0
Md:	Baltimore	21	1	0	0	7	68	6	60	0
Mass:	Lawrence	21	1	0	0	7	162	7	162	0
	Winchester	19	1	0	0	8	195	8	195	0
Mich:	Lansing	22	1	0	1	7	74	7	74	8
Minn:	Minneapolis	22	3	0	1	5	81	5	81	12
Miss:	Jackson	15	2	0	1	4	45	4	45	2
Mo:	Jefferson City	21	3	1	2	3	35	3	35	0
Mont:	Helena	18	2	0	1	3	28	3	28	0
Nebr:	Lincoln	16	8	0	3	2	42	2	42	4
Nev:	Las Vegas	20	3	1	2	0				
N.H:	Concord	0				0				
N.J:	Trenton	21	1	0	0	12	189	12	189	8
N. Mex:	Santa Fe	18	3	1	1	0				
N.Y:	Albany	19	1	0	0	0				
	Buffalo	20	2	0	1	0				
	New York City	0				0				
N.C:	Gastonia	18	8	0	3	2	83	[b]		
N. Dak:	Bismarck	20	5	1	2	3	34	3	34	2
Ohio	Cincinnati	0				0				
	Columbus	5	2	1	1	0				
	Painesville	20	1	0	0	12	187	12	187	31
Okla:	Oklahoma City	8	4	1	2	0				
	Ponca City	21	8	0	2	4	65	4	65	0
Oreg:	Portland	18	1	0	0	3	10	3	10	3
Pa:	Harrisburg	14	2	0	1	4	44	4	44	14
P.R:	San Juan	0				0				
R.I:	Providence	22	1	0	0	0				
S.C:	Columbia	16	3	0	1	2	109	2	109	0
S. Dak:	Pierre	22	6	0	2	0				
Tenn:	Nashville	22	2	0	1	7	47	7	47	2
Tex:	Austin	20	6	1	4	2	26	[b]		
	El Paso	21	4	0	1	0				
Utah:	Salt Lake City	28	2	0	1	1	2	1	2	1
Vt:	Barre	16	2	0	1	7	80	7	80	8
Va:	Richmond	18	1	0	0	1	21	1	21	10
Wash:	Seattle	9	0	0	0	5	49	[b]		
	Spokane	16	2	0	1	0				
W. Va:	Charleston	21	3	0	1	13	91	13	91	13
Wisc:	Madison	20	2	0	1	5	28	5	28	8
Wyo:	Cheyenne	20	7	1	3	1	9	1	9	4
Network summary		1,094	8	0	1	181	82	5	73	6

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

2. Canadian Air and Precipitation Monitoring Program, June 1972[1]

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1-5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for June 1972 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, June 1972

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	4	0.2	0.0	0.1	16	2.3
Coral Harbour	4	.1	.0	.0	13	1.1
Edmonton	4	.2	.1	.1	44	5.0
Ft. Churchill	4	.1	.0	.1	80	6.7
Fredericton	4	.1	.0	.1	48	5.9
Goose Bay	4	.1	.1	.1	31	3.5
Halifax	25	.3	.1	.1	44	5.1
Inuvik	4	.1	.0	.1	106	4.4
Montreal	4	.1	.0	.1	42	5.6
Moosonee	4	.1	.1	.1	160	3.3
Ottawa	4	.2	.1	.1	43	5.7
Quebec	4	.1	.1	.1	51	5.9
Regina	4	.2	.1	.1	154	7.2
Resolute	4	.0	.0	.0	203	1.9
St. John's, Nfld.	4	.1	.1	.1	41	4.0
Saskatoon	4	.2	.1	.1	97	5.6
Sault Ste. Marie	2	.1	.1	.1	157	4.7
Thunder Bay	4	.1	.1	.1	62	4.5
Toronto	4	.1	.1	.1	23	2.0
Vancouver	4	.1	.0	.1	79	3.7
Whitehorse	4	.2	.1	.1	57	2.0
Windsor	4	.2	.1	.2	104	7.0
Winnipeg	4	.2	.0	.1	122	6.1
Yellowknife	3	.1	.0	.1	NS	NS
Network summary	114	0.3	0.0	0.1	77	4.5

NS, no sample.

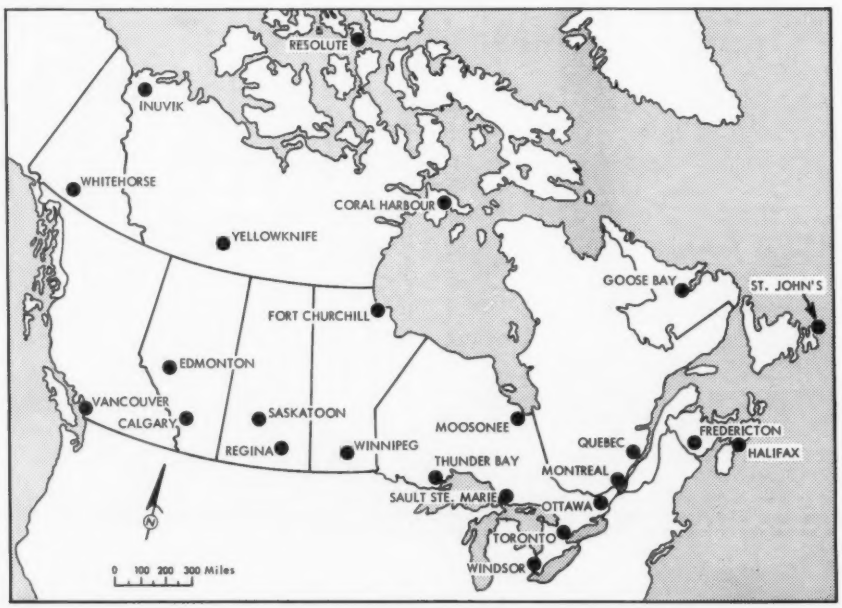

Figure 2. Canadian air and precipitation sampling stations

3. Pan American Air Sampling Program, June 1972

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The June 1972 air monitoring results from the participating countries are given in table 3.

Figure 3. Pan American Air Sampling Program

Table 3. Summary of gross beta radioactivity in Pan American surface air, June 1972

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average*
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	1	0.03	0.03	0.03
Chile:	Santiago	28	.12	.01	.04
Colombia:	Bogota	18	.04	.00	.01
Ecuador:	Cuenca	7	.03	.00	.01
	Guayaquil	10	.05	.01	.03
	Quito	16	.01	.00	.00
Guyana:	Georgetown	0			
Jamaica:	Kingston	0			
Peru:	Lima	0			
Venezuela:	Caracas	14	.07	.00	.03
West Indies:	Trinidad	11	.14	.04	.08
Pan American summary		105	0.14	0.00	0.03

*The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

4. California Air Sampling Program June 1972

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations, operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continu-

Figure 4. California air sampling program stations

ous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 4 presents the monthly gross beta radioactivity in air for June 1972. The monthly sample results are presented quarterly.

Table 4. Gross beta radioactivity in California air June 1972

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	29	0.97	0.14	0.44
Barstow	30	.84	.25	.54
Berkeley	28	.43	.01	.14
Colfax	30	.85	.15	.42
El Centro	30	1.25	.25	.53
Eureka	26	.19	.00	.09
Fresno	30	1.15	.04	.47
Los Angeles	30	.80	.08	.25
Redding	21	.66	.28	.41
Sacramento	30	.73	.12	.29
Salinas	30	.47	.08	.21
San Bernardino	30	.89	.12	.37
San Diego	29	.42	.06	.26
Santa Rosa	30	.64	.04	.21
Summary	846	1.25	0.00	0.33

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Air Surveillance Network, June 1972

National Environmental Research Center-Las Vegas, Environmental Protection Agency

The Air Surveillance Network (ASN), operated by the National Environmental Research Center-Las Vegas (NERC–LV),[1] consists of 104 active and 18 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing sponsored by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), by the Space Nuclear Systems Office at the Nuclear Rocket Development Station which lies within the NTS, and by the AEC at any other designated testing sites.[2]

[1] Formerly the Western Environmental Research Laboratory (WERL).

[2] The ASN is operated under a Memorandum of Understanding (No. AT926–1–539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

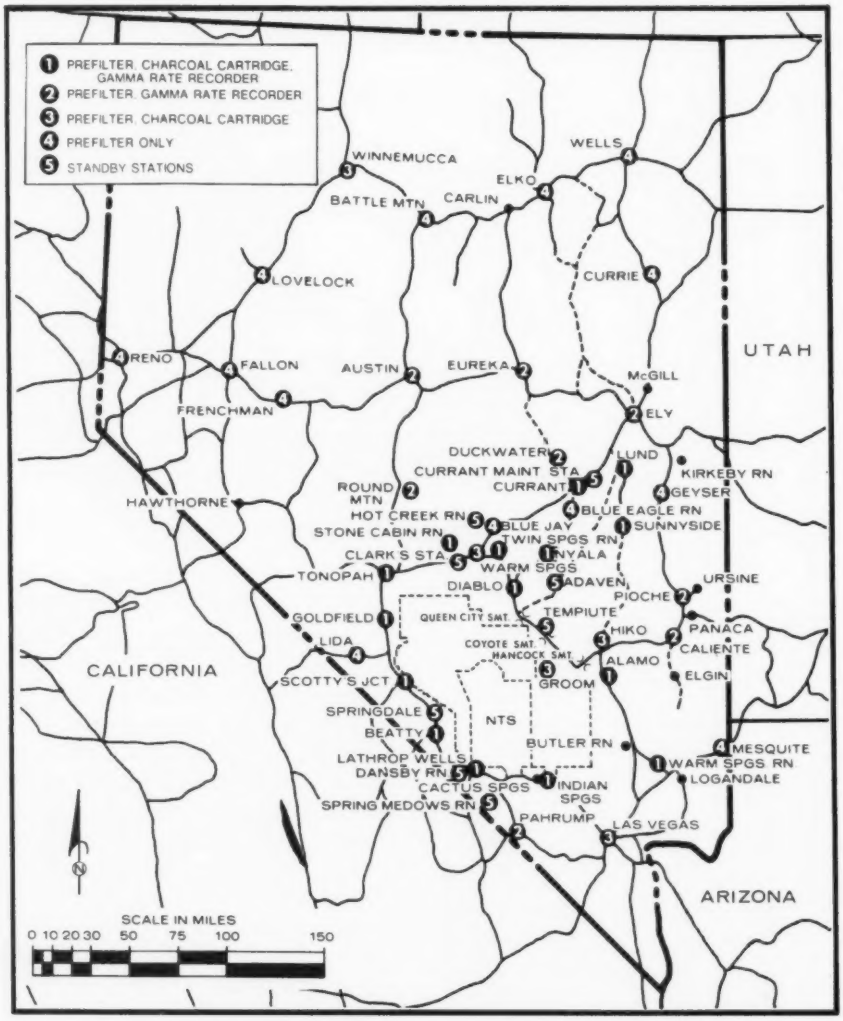

Figure 1. NERC-LV Air Surveillance Network stations in Nevada

Figure 2. NERC-LV Air Surveillance Network stations outside Nevada

The stations are operated by State health department personnel and by private individuals on a contract basis. Daily 24-hour samples are collected at each station. All samples are mailed to the NERC–LV unless special retrieval is arranged at selected locations in support of known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

Results

Table 1 presents the monthly average gross beta radioactivity in air particulates for each of the network stations. The minimum reported concentration for gross beta is 0.1 pCi/m^3; however, gross beta concentrations above the minimum detectable concentration of 0.06 pCi/m^3 are used in determining averages. Individual concentrations which are below the minimum detectable concentration are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reported level are reported as $<$0.1 pCi/m^3. The highest gross beta concentration within the network on a single filter during June was 1.4 pCi/m^3 at Currie, Nev.

Table 1. Summary of gross beta radioactivity concentrations in air, June 1972

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average[a]
Ariz:	Kingman	30	1.0	0.2	0.4
	Phoenix	27	.5	.1	.3
	Seligman	30	.5	<.1	.3
	Winslow	30	.4	.1	.3
Ark:	Little Rock	22	.5	<.1	.3
Calif:	Baker	29	.7	.1	.3
	Barstow	29	.6	.2	.4
	Bishop	30	1.3	<.1	.5
	Death Valley Junction	25	.8	.2	.5
	Furnace Creek	30	.8	<.1	.4
	Indio	30	.6	.1	.3
	Long Pine	30	.8	.2	.4
	Needles	26	.6	.2	.4
	Ridgecrest	28	.7	<.1	.4
	Shoshone	30	.7	.2	.4
Colo:	Denver	22	.6	.1	.3
	Durango	30	.8	<.1	.4
Idaho:	Boise	30	.6	<.1	.4
	Idaho Falls	22	.8	.2	.4
	Preston	30	.7	.2	.4
	Twin Falls	30	.6	.1	.4
Iowa:	Iowa City	22	.9	<.1	.3
	Sioux City	25	.5	<.1	.4
Kans:	Dodge City	30	.4	<.1	.3
La:	Lake Charles	21	.7	<.1	.2
	Monroe	23	.6	<.1	.2
	New Orleans	20	.6	<.1	.2
Minn:	Minneapolis	21	.4	<.1	.2
Mo:	Joplin	25	.5	<.1	.3
	St. Joseph	30	.7	.2	.4
	St. Louis	30	.6	.1	.4
Nebr:	North Platte	25	.5	.2	.3
Nev:	Alamo	30	.6	.1	.4
	Austin	23	.8	<.1	.4
	Battle Mountain	30	.7	.1	.4
	Beatty	30	.8	.1	.4
	Blue Eagle Ranch (Currant)	23	.7	.3	.4
	Blue Jay	30	.7	.2	.4
	Caliente	29	.7	.1	.4
	Currant Ranch	30	.9	.2	.4
	Currie	30	1.4	.1	.4
	Diablo	30	.7	.1	.4
	Duckwater	23	.8	.1	.4
	Elko	30	.7	<.1	.4
	Ely	27	.6	<.1	.3
	Eureka	30	.8	.2	.4
	Fallini's Twin Springs Ranch	30	.8	.2	.5
	Fallon	30	.6	.2	.5
	Frenchman Station	30	.6	.2	.4
	Geyser Maintenance Station	29	.8	<.1	.4
	Goldfield	29	.7	.2	.4
	Groom Lake	26	.8	.2	.4
	Hiko	30	1.3	<.1	.4
	Indian Springs	24	.7	<.1	.3
	Las Vegas	21	.7	<.1	.4
	Lathrop Wells	30	.7	.1	.4
	Lida	28	.7	.2	.4
	Lovelock	30	.9	.1	.4
	Lund	30	.6	<.1	.3
	Mesquite	30	.7	.2	.4
	Nyala	30	.9	<.1	.5
	Pahrump	18	.6	<.1	.3
	Pioche	28	.5	.2	.3
	Reno	30	.7	.2	.4
	Round Mountain	28	.8	.2	.4
	Scotty's Junction	29	.9	.2	.5
	Stone Cabin Ranch	30	.8	<.1	.4
	Sunnyside	28	.9	.2	.4
	Tonopah	30	.7	<.1	.4
	Tonopah Test Range	23	.7	.2	.4
	Warm Springs	28	.9	.2	.4
	Warm Springs Ranch	23	.7	<.1	.4
	Wells	30	1.0	.1	.4
	Winnemucca	30	.7	<.1	.4
New Mex:	Albuquerque	22	.6	<.1	.3
	Carlsbad	29	.5	<.1	.3
Okla:	Muskogee	30	.5	<.1	.3
Oreg:	Burns	30	.5	.1	.3
	Medford	23	.5	<.1	.2
S. Dak:	Aberdeen	30	.6	<.1	.3
	Rapid City	30	.7	<.1	.3
Tex:	Abilene	29	.5	<.1	.2
	Amarillo	30	.6	<.1	.3
	Austin	22	<.7	<.1	.2
	Fort Worth	30	.6	<.1	.3

See footnotes at end of table.

Table 1. Summary of gross beta radioactivity concentrations in air, June 1972—continued

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average[a]
Utah:	Bryce Canyon	27	.7	.1	.3
	Cedar City	29	.7	.1	.4
	Delta	28	.7	.1	.4
	Dugway	30	.9	<.1	.4
	Enterprise	30	.6	<.1	.4
	Garrison	30	.9	.1	.4
	Logan	29	.7	<.1	.4
	Milford	30	.8	<.1	.4
	Monticello	19	.7	<.1	.4
	Parowan	23	.8	.1	.4
	Provo	29	.8	.1	.4
	Roosevelt	30	.6	.1	.3
	Salt Lake City	29	.6	.1	.4
	St. George	30	.7	.1	.4
	Wendover	30	.7	<.1	.4
Wash:	Seattle	22	.3	<.1	.1
	Spokane	21	.5	.1	.2
Wyo:	Rock Springs	30	.7	<.1	.4
	Worland	30	.7	<.1	.3

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reporting value of 0.1 pCi/m³ is reported as <0.1.

From gamma spectrometry results, zirconium-95 and ruthenium-103, in varying combinations, were identified on filters collected in California, Missouri, and Nevada. The highest concentrations of these radionuclides, respectively, were 0.3 pCi/m³ (Death Valley Junction, Blue Jay, Groom Lake, and Tonopah Test Range), and 0.1 pCi/m³ (Austin, Nev.). These radionuclides are attributed to worldwide fallout.

Copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA regional offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC–LV upon written request.

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Offsite Surveillance Around the Nevada Test Site, July-December 1969[1]

National Environmental Research Center-Las Vegas,[2] and Nevada Operations Office, AEC

Under a Memorandum of Understanding with the U.S. Atomic Energy Commission, the Southwestern Radiological Health Laboratory (SWRHL) conducted its continuing program of radiological surveillance, including monitoring and environmental sampling in the public areas surrounding the Nevada Test Site (NTS) from July through December 1969. During this period, 15 announced underground nuclear tests were conducted at the NTS and two other events were conducted, Project Milrow in Alaska and Project Rulison in Colorado. One of the NTS tests, the Pod Event, released radioactivity that was detected offsite. In addition, one power run of the XE-Prime nuclear rocket engine conducted at the Nuclear Rocket Development Station (NRDS) released radioactive material to the offsite environment.

Operational procedures

Comprehensive ground monitoring capabilities were maintained throughout this period. Mobile ground monitoring teams were positioned in offsite areas prior to each event. Each monitor was equipped with an Eberline E–500B survey meter, a Baird-Atomic Model NE–148 Scintillator, and a Victoreen Radector, Model No. AGB–50B–Sr. Eberline RM–11 gamma-rate recorders were also utilized to document cloud passage at fixed ground locations. Aerial monitoring capabilities included two SWRHL cloud sampling aircraft and an Air Force U–3A aircraft with an Air Force pilot and two SWRHL monitors equipped with portable instruments identical to those of the ground monitoring teams.

Immediately after each release of radioactivity, this aerial monitoring team tracked the cloud, determined its relative radiation intensity, and reported its position, speed and direction to assist in the positioning of ground monitors. The SWRHL aircraft also aided in cloud tracking and collected samples in the cloud to assess the total radionuclide inventory of the release.

The SWRHL Air Surveillance Network (ASN) consisted of 103 stations operating in every State west of the Mississippi River except Montana and North Dakota (figure 1). Fifteen stations were added in Colorado in support of Project Rulison and 18 were added in Alaska in support of Project Milrow. The air sampler used was a Gelman "Tempest" which was equipped to use a 4-inch-diameter Whatman 541 filter paper and an MSA charcoal cartridge.

The routine milk sampling program was continued during the 6-month period during which 194 samples were collected from both commercial dairies and private producers. Including both potable and nonpotable supplies, 564 water samples were collected from about 95 sources.

[1] This article is a summary of report No. SWRHL–98r, "Off-Site Surveillance Activities of the Southwestern Radiological Health Laboratory from July through December 1969."

[2] Formerly Southwestern Radiological Health Laboratory, U.S. Department of Health, Education, and Welfare, Public Health Service, Bureau of Radiological Health.

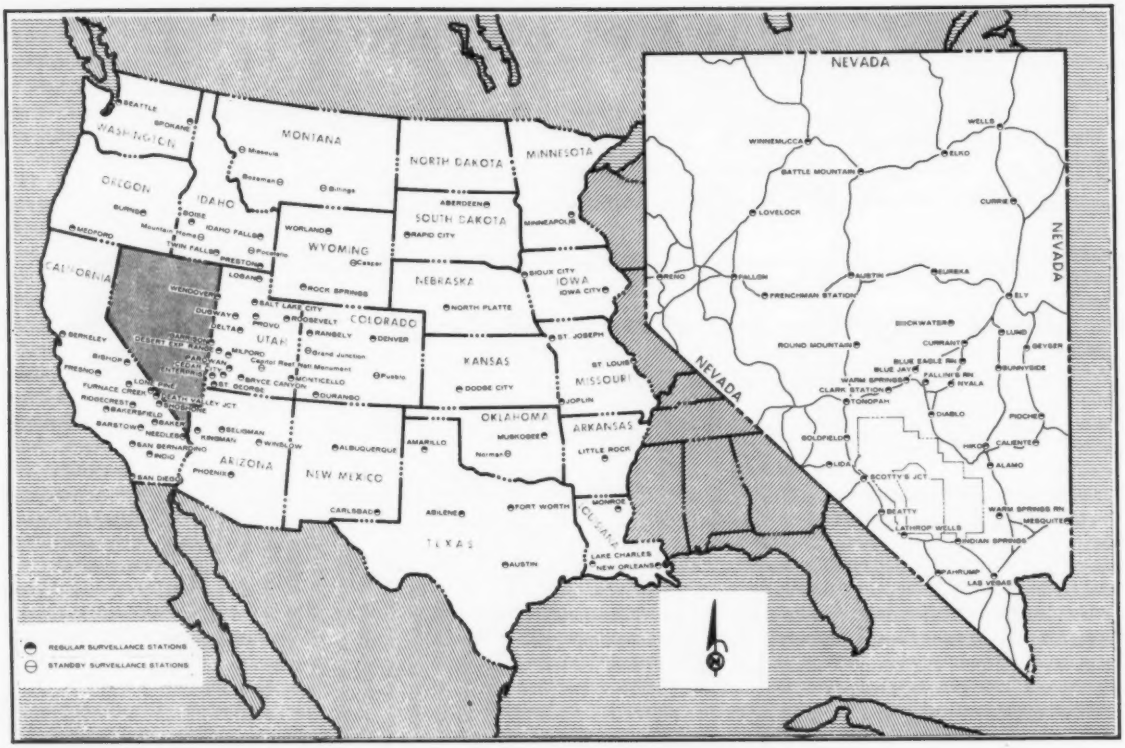

Figure 1. NERC-LV Air Surveillance Network stations

Vegetation samples, collected to delineate any fallout pattern, consisted of milk-cow feed samples taken at most locations where special milk samples were collected following known releases of radioactivity and natural vegetation samples collected along highways crossed by the cloud.

Approximately 87 residents in the offsite area wore film badges throughout this period. These film badges used DuPont type 545 film which records gamma exposures to an accuracy of ±50 percent in the 30 to 100 mR range and ±10 percent in the 100 to 2,000 mR range. In addition, 107 film badge stations, each with five film badges, were located around the NTS. Each station was also equipped with three EG&G Model TL–12 thermoluminescent dosimeters (TLD's).

A SWRHL medical officer was available to investigate reports of injuries alleged to be the result of the test series and to maintain liaison with local physicians. No injuries were reported. Veterinarian services were also provided by the SWRHL to conduct wildlife and domestic livestock investigations. Other community relations services included personal contact with offsite residents by route monitors and information presentations conducted at schools and civic centers. As a result, many offsite residents participated in the sampling program. All routine air sampling stations, except those in Las Vegas, were operated by local citizens.

Considerable additional coverage was provided in support of Project Milrow on Amchitka Island, Alaska, and for Project Rulison in Colorado. This effort consisted of pre- and postshot environmental sampling, the establishment of supplementary air surveillance networks and community information programs and, in the case of Rulison, preshot evacuation of local residents because of expected ground motion.

Table 1. Five highest iodine-131 results and associated gross beta and isotopic results from air sample media extrapolated to end of collection period (combined particulate and charcoal filter), XE–Prime, EP IXA, August 28, 1969

Location azimuth-distance from experimental test site-1	Time on off	Date on off (1969)	Average concentrations during collection period and integrated concentrations											
			Gross beta		Iodine-131		Tellurium-132		Iodine-133		Iodine-135		Strontium-91	
			pCi/m³	μCi-s/m³	pCi/m³	μCi-s/m³	pCi/m³	μCi-s/m³	pCi/m³	μCi-s/m³	pCi/m³	μCi-s/m³	pCi/m³	μCi-s/m³
Koyne's Mill, Nev.[a] 28°, 55 miles	1854 2054	8/28 8/28	5,000	36	62	0.45	150	1.1	280	2.0	560	4.1	120	0.86
Queen City Summit, Nev.[a] 8°, 67 miles	1925 2050	8/28 8/28	5,700	29	55	.28	170	.86	320	1.6	550	2.8	190	.96
Nyala, Nev. 18°, 103 miles	[b]0700 0700	8/28 8/29	11	.85	1.7	.13	3.0	.23	5.5	.42	ND	ND	ND	ND
Blue Eagle Ranch, Nev.[a] 19°, 123 miles	[d]0655 0620	8/28 8/29	11	.81	1.3	.10	2.9	.22	ND	ND	ND	ND	ND	ND
Lund, Nev. 27°, 158 miles	0758 0814	8/28 8/29	9.6	.84	.9	.08	2.1	.18	ND	ND	ND	ND	ND	ND

[a] Temporary station.
[b] Sampler operated for 21.4 hours during this period.
[c] No charcoal cartridge run.
[d] Sampler operated for 21.3 hours during this period.
ND, nondetectable.

Analytical procedures

Samples were returned to the SWRHL in Las Vegas for radiological analysis. Air sample particulate filters were counted for beta radioactivity in a Beckman Widebeta low-background, proportional counter system. Selected particulate filters, all charcoal cartridges, and water and milk samples were analyzed for gamma emitting isotopes; a 4- by 4-inch NaI(Tl) crystal coupled to a TMC model 404C gamma pulse height analyzer was used. The lower limit of detection for gamma emitters in air samples was 0.1 pCi/m³ for a 10-minute counting time and a sample volume of 350 m³/day. The lower limit of detection for gamma-emitters in 3.5-liter water and milk samples was 10 to 20 pCi/liter, depending on the counting time of 20 to 40 minutes. Gamma spectra were evaluated using a matrix technique which allowed for the simultaneous determination of eight nuclides.

Results

One of the underground tests during this period, the Pod Event conducted October 29, released radioactivity that was detected offsite. The maximum gross gamma exposure rate from this event was 0.06 mR/h, observed by ground monitors on GM survey instruments at Lathrop Wells and on Highway 95, 10 miles west of Highway Junction 95/16. Net exposure at both locations was less than 0.1 mR. No radiation above background was detected by gamma-rate recorders and no fresh fission products were found in milk, water or vegetation samples.

Experimental Plan IXA of the XE-Prime rocket engine test released radioactive effluent that was detected on seven ASN station air samplers and on three of the temporary samplers placed on highway 25 between Hancock Summit and Queen City Summit (table 1). Monitors detected cloud passage at Queen City Summit, Koyne's Mill and Coyote Summit. The peak radiation level was 0.04 mR/h on GM survey instruments. No radiation levels above background were measured by gamma-rate recorders and no fresh fission products were found in milk, water or cow feed samples. No dosimetry devices indicated exposures above background.

Conclusions

Results obtained through environmental radiation surveillance during the period July-December 1969 indicate that no individual in the offsite area received an exposure, resulting from NTS nuclear test activities, which exceeded the guides established by the AEC and/or recommended by the Federal Radiation Council.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

A summary of the environmental radioactivity data follow for the Knolls Atomic Power Laboratory and the Rocky Flats Plant.

[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Knolls Atomic Power Laboratory [2] January–December 1969

General Electric Company
Schenectady, N.Y.

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission (AEC), is to support the Naval Reactors Program of the AEC in the development of atomic power reactors for naval propulsion. This includes design, construction, and prototype operation of nuclear power reactors. The Knolls Atomic Power Laboratory consists of two sites, the Knolls site and the Kesselring site, located as shown in figure 1.

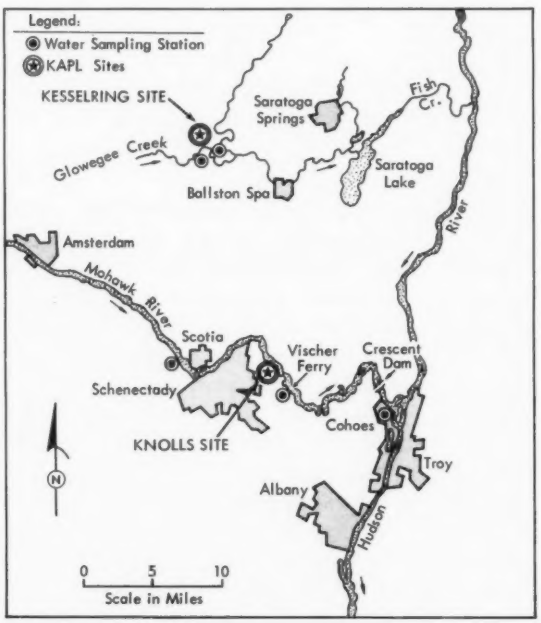

Figure 1. Environmental monitoring locations, KAPL

Knolls site

The Knolls site occupies approximately 170 acres on which are located administrative buildings; chemistry, physics, metallurgical, engineering, and radioactive materials laboratories; critical assembly buildings; machine shops, decontamination facilities; radioactive waste storage and processing facilities; and nuclear fuel storage and assembly buildings.

The Knolls site releases small amounts of radioactive materials both to the atmosphere and to the Mohawk River. Prior to the release, exhaust air and liquid waste are treated and carefully monitored. In addition to the in-plant control monitoring, an environmental monitoring program is conducted both on- and offsite at the Knolls site for the following purposes: 1) to audit the operational control of radioactive waste release to the environment, and 2) to ascertain compliance with the radioactivity standards established by the AEC.

[2] Summarized from "Knolls Atomic Power Laboratory, Knolls Site and Kesselring Site, Annual Environmental Monitoring Report, January–December 1969."

Air monitoring

Prior to the fourth quarter 1969, environmental airborne radioactivity was continuously sampled and analyzed on a weekly basis at two locations at the Knolls site and at the General Electric Company Research and Development Center, approximately 1 mile west of the Knolls site. This program was terminated after the third quarter since airborne radioactivity discharges are monitored at the point of discharge and portable air sampling equipment is available to measure radioactivity in the event of an accidental release of activity. In addition, in-stack radioactivity concentrations at the Knolls site average less than the appropriate concentration guides given in AEC Manual Chapter 0524.

For the first three calendar quarters of 1969, average beta-gamma concentrations in air were 100 fCi/m^3 and 110 fCi/m^3 at the Knolls and offsite sampling locations, respectively. The results were all less than the most restrictive environmental concentration guide for airborne beta-gamma emitting radionuclides given in AEC Manual Chapter 0524.

In addition to the environmental airborne radioactivity monitoring, surveys are made routinely of the radiation levels at the perimeter of the Knolls site facilities. The surveys of 1969 showed normal background radiation levels for the geographic location. The results of the surveys extrapolated to an annual exposure, indicate average radiation levels of < 0.1 R/a.

Liquid waste monitoring

All sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste processing building. The collected waste water is processed and sampled and the samples analyzed to verify that the radioactivity concentration and the total activity content of the processed waste are within established discharge limits. Subsequently, the processed waste water is discharged to the Mohawk River at a controlled rate. During discharge, samples are again collected and composite samples are analyzed on a monthly basis.

A continuous proportional sample of the Knolls site combined sewer effluent is collected at the point of release to the Mohawk River. The radioactivity concentration in the effluent is continuously monitored and recorded by passing a portion of the sample through an in-line, lead shielded gamma scintillation detection system. An aliquot of the collected sample is analyzed whenever an increase in the gamma count rate above the normal range of background fluctuations is observed on the recorder.

A total of 22.5 millicuries of beta-gamma and 5.0 millicuries of alpha activity was discharged to the Mohawk River during 1969. The annual average concentration of strontium-90, which comprised 32 percent of the total beta-gamma activity in the effluent, was 4.8 pCi/liter or 1.6 percent of its environmental standard as given in AEC Manual Chapter 0524. The annual average concentration for the uranium isotopes, which comprised 98.8 percent of the total alpha activity, was 3.3 pCi/liter which is less than 0.1 percent of their effective environmental concentration guide.

Water monitoring

Mohawk River water is sampled continuously at the General Electric Company powerhouse 8 miles upstream from the Knolls site, and at the Vischer Ferry powerhouse 1.7 miles downstream. The weekly water samples are composited and analyzed for radioactivity on a monthly basis.

Due to the lack of any statistical differences in the radioactivity concentrations in upstream and downstream water samples, during periods when the radioactivity discharges to the Mohawk River were higher by factors of 4,000

Table 1. Radioactivity in Mohawk River water near the Knolls site, 1969

Sampling period (1969)	Beta and gamma radioactivity[a] (pCi/liter)			
	G.E. Powerhouse (upstream)	Vischer Ferry (downstream)	Cohoes raw water (downstream)	Municipal water
January-March	<5.1	6	7	<5.1
April-June	<5.1	<5.1	<5.1	<5.1
July-September	7	7	NS	NS
October-December	<5.1	14	NS	NS

[a] Minimum detectable concentration, 90-percent confidence level: 5.1 pCi/liter. Concentration detectable at 90-percent confidence level with ± 30 percent precision: 19 pCi/liter.
NS, no sample, program terminated effective July 1, 1969.

or more than the annual discharge limit now in effect, the Cohoes water sampling program was discontinued effective the third quarter of 1969.

The average beta-gamma concentrations in Mohawk River water samples for each calendar quarter of 1969 are shown in table 1. The quarterly average concentrations were all significantly less than the most restrictive environmental concentration guide for strontium-90 given in AEC Manual Chapter 0524.

Sediment monitoring

The Mohawk River sediment monitoring program at the Knolls site consists of the collection and analyses of Mohawk River sediment in each of three calendar quarters; ice coverage prevents collection during the first calendar quarter. Samples are collected at 15 specific locations and all are analyzed for gamma, gross beta and alpha radioactivity. In addition, three of the samples are analyzed for strontium-90.

The average radioactivity concentrations in the quarterly samples of Mohawk River sediment for 1969 are given in table 2. The results indicate that the Knolls site radioactive liquid waste disposal program did not significantly influence the current radioactivity levels of the river sediment. In two of the three quarters, the sample location yielding the highest result was the location directly downstream from the Knolls site sewer outfall to the river. General concentrations rapidly diminished with increased distances from the sewer outfall.

Mohawk River fish radioactivity

Prior to 1969, samples of Mohawk River fish had been collected on an annual basis. A review of the monitoring data indicated no statistically significant difference between results obtained during periods of high radioactivity releases and recent periods in which releases were smaller by factors of 4,000 or more. On the basis of these results and the present low levels of annual discharge, the fish sampling program was terminated, effective 1969.

Kesselring site

The Kesselring site, located on approximately 4,000 acres near West Milton, N.Y., is a part of the Knolls Atomic Power Laboratory. Its principal facilities include the Triton (S3G) and Bainbridge (D1G) prototype reactors, equipment service building, fuel service building, and waste treatment facilities. Regular environmental monitoring activities are conducted to assure that laboratory releases of radioactivity to the environment are in compliance with AEC standards.

Air monitoring

During the first two quarters of 1969, environmental airborne radioactivity was continuously sampled and analyzed on a semiweekly basis at one location on the Kesselring site. This program was terminated after two quarters since airborne radioactivity discharges are monitored at the point of discharge and port-

Table 2. Radioactivity concentrations in Mohawk River sediment, KAPL, 1969 [a]

Sampling period (1969)	Number of samples	Total radioactivity (pCi/g dry weight)				Strontium-90 (pCi/g dry weight)		Cesium-137 (pCi/g dry weight)	
		Alpha		Beta					
		Average	Range	Average	Range	Average	Range	Average	Range
January-March	[b]NS								
April-June	15	0.63	0.2–0.9	48	20–90	<0.84	<0.84	4.66	0.5–10.3
July-September	15	.35	<.15–.8	50	34–83	<.84	<.84	1.1	.5– 4.9
October-December	15	.38	<.15–.6	30	14–51	<.84	<.84–.9	.86	.4– 3.0

[a] Minimum detectable concentration for a 600 g sample of 90-percent confidence level: alpha—0.15 pCi/g; beta—6.7 pCi/g; strontium-90—0.84 pCi/g and cesium-137—0.26 pCi/g. Concentration for 600 g sample detectable at 90-percent confidence level with 30 percent precision: alpha—0.85 pCi/g; beta—25 pCi/g; strontium-90—3.0 pCi/g, and cesium-137—0.94 pCi/g. The variation in the detectable levels is the result of differences in the size of sediment aliquots analyzed; i.e., alpha analysis, 10 g; beta analysis, 1 g; strontium-90, 10 g; cesium-137, total sample. Each sediment sample represents a surface area of 230 cm².

[b] Samples not collected due to ice on the Mohawk River.

able air sampling equipment is available to measure radioactivity in the event of an accidental release of activity. The average long-lived beta-gamma concentration in the environmental air was 0.26 pCi/m³ during the first two quarters. In-stack radioactivity concentrations averaged less than the appropriate concentration guides given in the AEC Manual Chapter 0524 for the second two quarters.

In addition to the environmental airborne radioactivity monitoring, surveys are made semiannually of the radiation levels at the Kesselring site perimeter. Perimeter surveys performed during the year showed normal background radiation levels for the geographic location. The result of the perimeter survey extrapolated to an annual exposure indicates average perimeter radiation levels of <0.1 R/a.

Radioactive liquid waste disposal

The liquid waste from the Kesselring site is collected, processed, and sampled prior to release to the Glowegee Creek. The radioactive waste discharged to the Glowegee Creek in terms of total radioactivity in liquid wastes was 3.4 millicuries for 1969. Radiochemical analyses of these wastes indicated that strontium-89 and strontium-90 concentrations were less than 1 percent of the respective AEC standards for this reporting period. The average result for unidentified radionuclides in the D1G and S3G effluents (9.8 and 56 pCi/liter) represent less than 1 percent and less than 2 percent, respectively, of the applicable AEC standard (3 nCi/liter).

Water monitoring

Samples of the Glowegee Creek water are analyzed for radioactivity once each quarter year at two locations. One is about 150 feet above the point where the S3G effluent enters the creek and the other is about 1,500 feet below the D1G effluent discharge point.

The average concentrations of beta and gamma radioactivity detected in Glowegee Creek water upstream and downstream from the S3G and D1G liquid-waste outfalls are shown in table 3. All but one Glowegee Creek water analysis results were below 50 pCi/liter which is the measured concentration that may be considered valid at the 90-percent confidence level with a maximum error of 30 percent.

Table 3. Radioactivity in Glowegee Creek water from the Kesserling site operations, KAPL, January–December 1969

1969	Average beta and gamma concentrations (pCi/liter)	
	Glowegee Creek (upstream)	Glowegee Creek (downstream)
January–March	<50	<50
April–June	<50	<50
July–September	<50	111
October–December	<50	<50
Calendar year total	<50	<65

Sediment monitoring

Glowegee Creek sediment radioactivity measurements are analyzed on a monthly basis. Sample locations are the same as those listed for Glowegee Creek water sampling. The sediment analysis results are shown in table 4.

Table 4. Radioactivity in Glowegee Creek sediment, KAPL, January–December 1969

1969	Location	Number of samples	Gross-gamma radioactivity (pCi/g dry weight)		Cobalt-60 (pCi/g dry weight)
			Average	Range	
January–March	Upstream	NS			
	Downstream	1	9.8		1.20
April–June	Upstream	*2	9.1	7.5–10.7	1.35
	Downstream	*2	14.5	14.0–15.0	1.25
July–September	Upstream	3	12.8	9.9–18.0	1.46
	Downstream	3	15.2	10.7–18.6	2.66
October–December	Upstream	3	10.1	7.[illegible]–14.6	1.62
	Downstream	3	12.7	11.0–18.6	1.84

* No samples taken during May.
NS, no sample, creek bottom frozen.

General conclusions

As a result of the environmental monitoring program conducted by the Knolls Atomic Power Laboratory, it is concluded that the operation of the Knolls and Kesselring installations did not adversely affect the radioactivity levels of the local environment. The results of the environmental surveys indicate that the levels of radioactivity detected at all times were within the standards established by the U.S. Atomic Energy Commission in the AEC Manual Chapter 0524, Radiation Protections Standards.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–December 1968	October 1970

2. Rocky Flats Plant [3] January–December 1969

Dow Chemical Company
Golden, Colo.

The Rocky Flats Plant (RFP) is engaged in routine production operations involving plutonium and uranium under contract to the Atomic Energy Commission. Its location, relative to population centers, is shown in figure 2. The basic goal guiding these operations is total containment of radioactive materials. The environmental survey program is designed to assure that radioactive materials released are below the AEC standards. Following a fire in a plutonium production building on May 11, 1969, environmental monitoring was intensified and expanded to include specific plutonium analyses of air, water, vegetation, and soil samples as well as gross alpha analyses (uranium plus plutonium) as previously performed.

The plant is located about 15 miles northwest of Denver. The surface stratum in this area consists of gravel washed out of the highly mineralized front range of the Rocky Mountains, where heterogeneous low-level deposits of uranium, thorium, and radium exist in the soil. These materials are measurable in most samples of air, water, and vegetation.

Air

Air samples from samplers programmed to operate 5 minutes of each hour were collected at Coal Creek Canyon, Marshall, Boulder, Lafayette, Broomfield, Wagner Station, Golden, Denver, and Westminster. The monthly average gross alpha radioactivity is shown in table 5. Fallout trays are mounted at the sampling stations as well as several other standby stations. Plutonium radioactivity in fallout is sum-

[3] Summarized from "Environmental Survey, July–December 1969," The Dow Chemical Company, Rocky Flats Division, Golden, Colo.

Table 5. Gross long-lived alpha radioactivity in offsite air samples, RFP environs July–December 1969

Location	Average concentration (fCi/m³)					
	July	August	September	October	November	December
Boulder	12	10	8	8	8	8
Broomfield	10	24	8	10	8	10
Coal Creek	10	8	10	8	10	6
Denver	8	18	8	8	12	6
Golden	12	12	10	10	10	6
Lafayette	8	8	12	10	10	6
Marshall	20	42	18	18	16	10
Wagner Station	12	8	10	8	10	2
Westminster	16	10	10	14	12	10

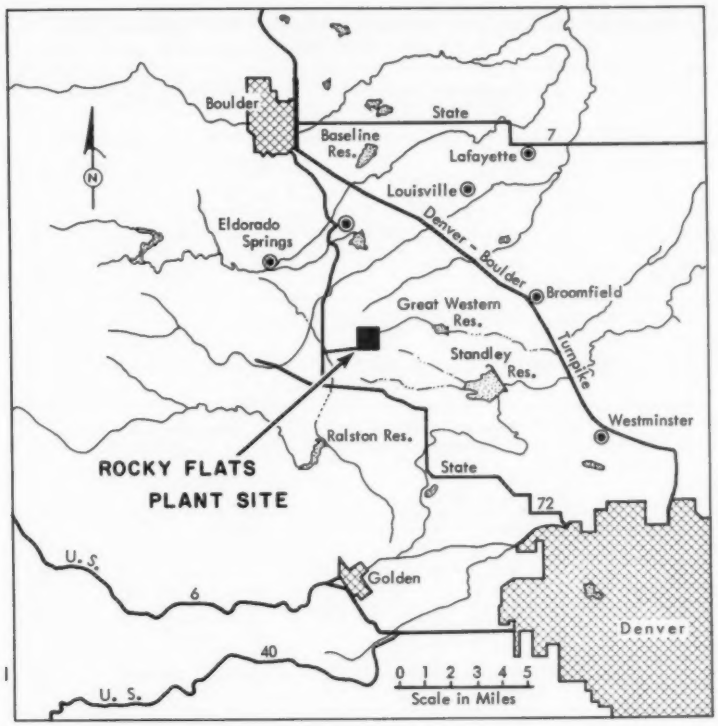

Figure 2. Location of Rocky Flats Plant

marized in table 6. In addition to the air sampling program, 8-hour high-volume air samples are collected periodically at one of the sampling stations. These samples are analyzed specifically for plutonium.

Table 6. Plutonium radioactivity in fallout, RFP environs, July–December 1969

Location	Number of days measured	Average plutonium radioactivity (pCi/m²-month)*
Arvada	133	1.73
Boulder	135	9.61
Broomfield	137	2.05
Coal Creek	125	5.72
Denver	151	1.84
Eastlake	140	13.3
Golden	125	3.24
Lafayette	151	2.38
Marshall	151	3.89
Superior	151	3.46
Wagner Station	151	20.0
Westminster	151	1.51

* This includes worldwide fallout.

Water

Four reservoirs in the area are sampled biweekly. Local community tap water samples are collected monthly. Other streams and lakes in the area are sampled twice a year. These samples are analyzed for gross alpha radioactivity content (uranium plus plutonium). Selected samples are analyzed for plutonium by alpha spectrometry. Tables 7 through 9 summarize the results of the water sampling program. The concentration guide for radioactivity above natural background for water (applicable to the averaged annual levels) is 10 pCi/liter where the concentration of individual radionuclides is not known and 1,600 pCi/liter for plutonium-239. These guides apply to the general population.

Table 7. Radioactivity in reservoir samples, RFP environs, July–December 1969

Reservoir	Gross alpha radioactivity (plutonium + uranium) (pCi/liter)			Plutonium radioactivity (pCi/liter)		
	Number of samples	Range	Average	Number of samples	Range	Average
Baseline	9	0.1– 3.3	1.0	4	<0.01–0.005	0.02
Great Western	[a] 24	.4– 5.0	2.1	4	.07– .25	.12
Ralston	10	1.1–13.2	5.7	6	< .01– .20	.06
Standley	[a] 24	.2– 4.4	1.6	3	< .01– .05	.02

[a] Additional samples were collected following the May fire.

Table 8. Radioactivity in community tap water, RFP environs, January–December 1969

Station	Gross alpha radioactivity (plutonium + uranium) (pCi/liter)			Plutonium radioactivity (pCi/liter)		
	Number of samples	Range	Average	Number of samples	Range	Average
Arvada	8	0.2–11.4	2.6	4	<0.01–0.07	0.04
Boulder	8	.1– .8	.4	3	< .01– .08	.03
Broomfield	8	.1– .9	.5	3	< .01– .06	.02
Denver	9	.2–10.	2.2	3	< .01– .11	.04
Golden	8	.1– 2.5	.8	3	< .01– .10	.05
Lafayette	9	.1– 1.7	.7	3	< .01– .02	.01
Louisville	9	.1– 1.9	.7	3	< .01– .01	<.01
Thornton	8	.2– 7.7	1.6	3	.05– .10	.08
Westminster	10	.8– 2.6	2.6	4	< .01– .40	.13

Table 9. Radioactivity in surface water, RFP environs, 1969 [a]

Sampling Date (1969)	Gross alpha radioactivity (plutonium + uranium) (pCi/liter)			Plutonium radioactivity (pCi/liter)		
	Number of samples	Range	Average	Number of samples	Range	Average
May–June	53	0.1–[b]16	1.8			
August	24	< .1–[c]27	3.1	5	<0.01–[d]1.24	0.13
Total	77	<0.1–27	2.2			

[a] Other than those presented in tables 7 and 8.
[b] Walnut Creek at Indiana Avenue.
[c] Long Lake.
[d] Plant effluent course at east cattle fence.

Vegetation

Vegetation samples have been collected semi-annually. These samples are radiochemically analyzed for uranium and plutonium. Results are summarized in table 10. With the implementation of extensive fallout and soil sampling programs, vegetation sampling will be cut back in future years.

Table 10. Gross alpha radioactivity in vegetation samples, RFP environs, 1969

Sampling date (1969)	Distance from plant (miles)	Number of samples	Gross alpha radioactivity (uranium + plutonium) (pCi/kg dry weight)	
			Range	Average
May–June	<4	72	<10–290	78
	4–18	43	<10–330	78
August–September	<4	54	<10–260	58
	4–18	44	<10–390	64

Soil

Soil samples are taken from the surrounding area, at remote locations, and from lake sediments. These are analyzed for plutonium and strontium-90. The plutonium-239-strontium-90 ratio is calculated as a basis of comparison with ratios established in worldwide fallout of bomb debris. Plutonium results are summarized in table 11 through 13. Strontium-90 results will be reported in subsequent reports.

Table 11. Plutonium radioactivity in vegetation samples, RFP environs, 1969

Sampling date (1969)	Distance from plant (miles)	Number of samples	Plutonium radioactivity (pCi/kg dry weight)	
			Range	Average
May-June	<4	72	<5–160	20
	4–18	43	<5–225	14
August-September	<4	54	<5–130	16
	4–18	44	<5–350	24

Table 12. Plutonium in surface soil samples, RFP environs, January–December 1969

Distance from plant (miles)	Number of samples	Plutonium content (dpm/g)	
		Range	Average
1	11	1.2–3.9	1.9
2	21	.4–6.7	1.4
5	16	.5–3.3	1.0
>5	14	.1– .6	.2

Table 13. Plutonium in reservoir sediments, RFP environs, January–December 1969

Reservoir	Number of samples	Plutonium content (dpm/g)	
		Range	Average
Great Western	9	0.3–2.4	1.0
Baseline	4	.1–1.3	.6
Ralston	4	.5– .9	.7
Standley	4	.5–1.0	.7

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1969	February 1970

Reported Nuclear Detonations, September 1972

(Includes seismic signals presumably from foreign nuclear detonations)

The U.S. Atomic Energy Commission announced that it had conducted two nuclear tests during September 1972.

On September 21, 1972, one nuclear test in the low-intermediate yield (20-200 kilotons TNT equivalent) was conducted underground at the Nevada Test Site by the Atomic Energy Commission.

The other test was of low yield (less than 20 kilotons TNT equivalent) and was conducted underground on September 26, 1972 at the Atomic Energy Commission's Nevada Test Site.

Seismic signals, presumably from a Soviet underground nuclear explosion were recorded by the United States. The signals originated at approximately 5:00 a.m., EDT, September 21, 1972, in the southern Ural area of the USSR, and were equivalent to those of an underground nuclear explosion of the yield range of 20-200 kilotons.

Information in this section is based on data received during the month, and is subject to change as additional information may become available. Persons requiring information for purposes of compiling announced nuclear detonation statistics are advised to contact the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

A COMPARISON OF FILM BADGES AND THERMOLUMINESCENT DOSIMETERS USED FOR ENVIRONMENTAL MONITORING. *Charles K. Fitzsimmons, William Horn,* and *William L. Klein. Radiation Data and Reports, Vol. 13, October 1972,* pp. 537-546.

Data obtained from two concurrent dosimetry networks operated by the National Environmental Research Center, Las Vegas, Nev., are compared. One network utilizes the film badges and the other, thermoluminescent dosimeters (TLD). Gamma exposures from a few mR to approximately 1 R due to both natural background and fission products in the environment are more easily and accurately measured by the TLD system. Where the minimum detectable exposure for film is about 45 mR, the TLD sensitivity is on the order of 1 mR (which allows measurement of monthly background exposures). The insensitivity of TLD's to environmental heating, humidity, light damage, and pressure makes them ideal for use in the extreme conditions encountered in the desert. Heat damage to the film was seasonal with the greatest losses occurring in the summer. During July 1967, 71 percent of the film badges issued were heat or light damaged, while no loss of TLD data occurred. No background information was obtained from film data during 1967, but the geographical variations in background exposure rates were clearly disclosed by the TLD's.

KEYWORDS: background exposure, environment, film badges, gamma radiation, Nevada Test Site, thermoluminescent dosimeters.

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